

A REPORT TO CONGRESS

**Surface Transportation
Research and Development Plan**

Fourth Edition

**A Report of the Secretary of Transportation
Pursuant to the
Intermodal Surface Transportation Efficiency Act of 1991
Section 6009(b), P.L. 102-240**

A Report to Congress

Surface Transportation Research and Development Plan

Fourth Edition

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Surface Transportation Research and Development Plan

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EXECUTIVE SUMMARY

Surface Transportation Research and Development Plan

Fourth Edition

Introduction

Section 6009(b) of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requires that the U.S. Department of Transportation (DOT) develop an integrated National Surface Transportation Research and Development (R&D) Plan that focuses on the research needed over the next decade. The congressionally mandated objectives of the plan are as follows:

- (1) To develop a range of technologies needed to produce convenient, safe, and affordable modes of surface transportation to be available for public use beginning in the mid-1990's; and,
- (2) To maintain a long-term advanced R&D program in order to provide for the next generation of surface transportation systems.

These objectives lead directly to the structure of the plan, which focuses on two time periods:

- (1) A Near-Term section (Section III, Chapters 1-8), which focuses on ongoing or projected programs and their conduct over the next three years; and,
- (2) A Long-Term section (Section II, Chapters 1-6), which focuses on the directions of DOT's transportation R&D over the next ten years and beyond.

In addition, the Government Performance and Results Act of 1993 (GPRA) has emphasized the need for strategic planning and mechanisms for performance assessment in Federal executive agency programs. This edition of the plan, which is the fourth to be issued, therefore has begun to examine ways to assess R&D program content and impacts, and for the first time discusses alternative approaches to doing this.

Long-Term Research Directions

Transportation R&D is a major lever in helping the nation accomplish its goals in transportation and other sectors of our society. The DOT R&D program must, therefore, support the directions established in the DOT Strategic Plan. The third edition of the plan emphasized the development of the link between R&D programs and accomplishment of Departmental goals. It evolved a series of 16 research thrusts, cutting across all surface

modes. This set of thrusts, however, only began to consider programs outside of DOT's, support of non-transportation objectives, and set priorities among program choices.

There were three major drivers over the last year which have started to move the Department and, hence, the Plan to address longer-time horizons and national-scale policy issues.

- In September 1996, the General Accounting Office (GAO) completed a detailed assessment of DOT's Surface Transportation R&D Program, summarized in the report *Surface Transportation: Research Funding, Federal Role and Emerging Issues*. The study concluded that DOT's research focused on improving individual modes of transportation, rather than on creating an integrated framework for needed research. It found investment in surface transportation research was inadequate to build knowledge in the areas of system assessment, policy research and intermodal research, as well as in basic, long-term, high-risk research. A more strategic perspective was needed in DOT's R&D program development.
- The GPRA requires the development and use of performance measures for agency management, and may ultimately lead to their use in allocating budgets. It also requires Government-wide implementation of strategic planning, annual planning, and program goal-setting with "objective, quantifiable, and measurable" indicators of performance. DOT is implementing the mandates of GPRA throughout all its programs, not just in the R&D area.
- The National Science and Technology Council's (NSTC's) Interagency Coordinating Committee on Transportation R&D prepared the first-ever government-wide *Transportation Science and Technology Strategy*. As the highest-level technical coordinating body in the Federal government, the NSTC has played a key role in helping to prioritize the Government's transportation R&D investments. The NSTC Strategy provides a framework for guiding Federal transportation R&D toward meeting national transportation system goals, not simply Departmental or surface transportation system ones. The Strategy is based on the results of numerous outreach events, environmental scans, and an analysis of the transportation system's current and future strengths, weaknesses, opportunities, and threats.

DOT has, therefore, refined its approach to R&D program planning. The intent of this year's plan is to use the GAO findings and recommendations, the GPRA implementation activities, and the NSTC's strategy formulation efforts to have national goals and performance measures guide Federal transportation R&D investments. Then, over time, it will be able to measure the impacts of those R&D investments on the performance of the nation's transportation system.

The DOT R&D plan has therefore adopted the NSTC Strategy's conceptualization of a coordinated Federal science and technology program, and how its elements must relate. The Strategy establishes a four-tiered approach:

1. Strategic Planning and Assessment activities establish how specific technologies can support achievement of national priorities.
2. Strategic Partnership Initiatives link governments at all levels, industry, and academia to bring the most needed, highest payoff technologies into widespread use.
3. Enabling Research develops knowledge and technological improvements which can then make possible solutions to transportation problems, or provide new transportation options.
4. Transportation Education and Training provides the cadre of competent transportation professionals to develop and apply new options and technologies.

Consistent with the NSTC's guidance, the DOT Surface Transportation R&D Plan then places its emphasis on the following partnership initiatives in surface transportation:

Transportation Information Infrastructure

- Smart Vehicles and Operators
- National Intelligent Transportation Infrastructure
- Enhanced Transportation Weather Services
- Enhanced Goods and Freight Movement at Domestic and International Gateways
- Accessibility for Aging and Transportation-Disadvantaged Populations
- Local Environmental Assessment Systems

Next-Generation Vehicles

- Next-Generation Motor Vehicles and Ships

Transportation Physical Infrastructure

- Total Terminal Security
- Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure
- Environmental Sustainability of Transportation Systems

The DOT Surface R&D plan also highlights six enabling research areas that support long-term national transportation goals. These are typically project areas whose benefits are too widely spread for any one company to recover its investment, whose cost or risk is too great for one

company to bear, and whose benefits are too far in the future to meet private investment criteria:

Enabling Research Topics

- Human Performance and Behavior
- Advanced Materials
- Computer, Information, and Communication Systems
- Energy and Environment
- Sensing and Measurement
- Tools for Transportation Modeling, Design and Construction

These top-priority partnership initiatives and enabling research topics are remarkably consistent with the research thrusts identified in the Third Surface Transportation R&D Plan.

Table III-1-1 presents the linkages between the partnership initiatives and those thrusts.

In addition, the document examines how to measure the success of, and establish future directions for, these longer-term research projects. It differentiates between "outcome" measures, which characterize the impacts of R&D once implemented, versus output measures, which document the products generated by the research efforts themselves. The indicators currently used by DOT in conducting assessments of the success of its research are collected and discussed.

Shorter-Term Research Directions

DOT's ongoing research activities make important contributions in the long-term areas highlighted above. DOT has active research proceeding on a variety of topics:

Physical Infrastructure

R&D includes development of stronger more durable, less expensive, easier-to-maintain materials; nondestructive testing and infrastructure monitoring techniques; improved design and construction practices; recycling and re-use of byproducts and waste products; and designs and construction approaches for more effective intermodal facilities.

Information Infrastructure

R&D includes network-based approaches to traffic control; collision warning and avoidance systems; technology for automated vehicle control and information systems; positive train control; developing the capacity to deal with hazardous materials incidents; antilock braking systems; vehicle safety information systems; information systems for drivers and other travelers; and advanced vehicle fleet management techniques.

Next Generation Vehicles and Fuels

R&D includes identifying near-term options for improving motor carrier safety; improving vehicle safety for children riding in passenger vehicles; evaluating the characteristics of vehicle crashes to determine hazards and safety needs; developing countermeasures for improved frontal crash protection; developing improved crash test dummies; developing nonelectric high-speed passenger locomotives; examining the safety of tilting high-speed rail cars; continuing the development of advanced transit bus technology; and developing and applying fuel cells in transportation vehicles.

Human-Centered Transportation Systems

R&D includes continuing work to identify and reduce the impacts of driver fatigue on transportation safety; developing improved displays for vehicle operators and controllers; developing a better understanding of the degrees of impairment associated with specific blood alcohol levels; developing more effective applications of advanced navigation technologies to improve safety; improving the placement and level of integration of vehicle gauges for transportation drivers; and updating drug and alcohol program implementation guidelines.

Intermodal Systems Assessment, Design, Planning, Management, and Operations

R&D in this area includes analysis of the sustainability of transportation systems; exploring the capability of supercomputer-based transportation planning models; continuing development of the National Advanced Driving Simulator (NADS); identification of injury mechanisms and outcomes in vehicle crashes; development of services to meet the special mobility needs of children, the elderly, and the handicapped; conducting "Bridges to Work" demonstrations to help unemployed inner-city dwellers rejoin the workforce; and examination of innovative financing techniques for transportation.

The document also explores the potential of DOT's cooperative programs with various sectors of the transportation industry through university based research and training programs; cooperative research programs with state and local governments; and fellowships to help continue the education of promising transportation professionals. Closely related, improvements in procurement and research support mechanisms also hold significant promise for improving the quality and responsiveness of America's transportation R&D to its national needs.

SECTION I: INTRODUCTION

Surface Transportation Research and Development Plan

Fourth Edition

I.a. The Role of Transportation in Society

The high level of mobility and access made possible by the US transportation system is critical to the economic well-being and quality of life of all Americans. The average person in the US travels approximately 17,000 miles annually, and 12,600 ton-miles of freight is moved each year per person. The ability to live far from the workplace, stores, and entertainment, to drive hundreds of miles on a weekend, or to fly across the country or to another continent on vacation or business, traveling whenever one wishes at an affordable cost, is a key component of most Americans' definition of a high level of quality of life. Indeed, on average, about 18 percent of household expenditures are for transportation.

More generally, transportation is an essential element in the functioning of the US economy. The sheer physical size of the US makes a high-quality, high performance and efficient national transportation system central to our economic efficiency and global competitiveness. Approximately 8 percent of the US workforce is employed in transportation-related functions, and total expenditures on transportation represent 11 percent of the gross domestic product.

The Nation's transportation system is vast in scope, including 3.9 million miles of roads, 1.4 million miles of oil and natural gas pipelines, 123,000 railroad route miles, and 26,000 miles of navigable waterways. There are more than 5,000 public-use airports, over 500 public transit operators, and 145 major ports. This infrastructure carries more than 4 trillion passenger-miles of travel and 3 trillion ton-miles of freight each year. There are nearly 200 million automobiles and light trucks—1.8 personal motor vehicles per household—that provide 87 percent of the total passenger-miles traveled. Most of the remainder is associated with 5,500 commercial airliners, nearly 740,000 buses of all kinds, 11,000 rail transit cars, and 2,000 intercity passenger railcars. The freight fleet encompasses 1.7 million combination trucks and nearly 6000 freight cars, as well as 31,000 barges, 5,000 towboats, and about 40,000 inland waterway vessels.

The physical presence and operation of this large and varied transportation system carries with it significant adverse societal impacts which pose a continuing challenge to the entire transportation community. While the US transportation system remains the safest in the world, and has shown steady improvement in this regard during the last several decades, it still accounts for almost half of all accidental deaths—more than 43,000 per year currently, about 95 percent of which arise in motor vehicle mishaps. The societal cost of transportation deaths, injuries and property damage has been estimated at \$150 billion per year.

Transportation activities are a significant source of environmental pollutants and other adverse effects. Highway vehicles alone produce a substantial fraction of four of the six pollutants for which the Environmental Protection Agency has set ambient air quality standards, and transportation as a whole is responsible for about one-third of US emissions of carbon dioxide, the primary greenhouse gas associated with potential global climatic change. Other societal impacts of transportation include noise, water and groundwater contamination, oil spills, oil storage leaks, solid wastes, and scrappage of vehicles and components (e.g., batteries and tires).

I.b. National Vision, Strategic Goals and Measures for Transportation

More than ever before, technological leadership is vital to our national interests. As stated in the recent National Science and Technology Council (NSTC) report, *Technology in the National Interest*, "Our ability to harness the power and promise of leading-edge advances in technology will determine, in large measure, our national prosperity, security, and global influence, and with them the standard of living and quality of life of our people."

Technology is particularly essential to the health of our transportation system. America's transportation system comprises a growing network of highways, transit systems, railroads, waterways, airports, airways, seaports, and pipelines that is critical to the nation's vitality and economic well-being. Innovations in transportation contribute to America's global competitiveness and national security. They enhance our environment and local communities. And, perhaps most importantly, they save lives and reduce the risk of accidents and injuries.

The NSTC Coordinating Committee on Transportation R&D (CTRD) recently completed the *Transportation Science and Technology Strategy* as a rationale and framework for guiding Federal long-term, strategic research and technology development that will make our transportation system safer, more productive, and more efficient. The Strategy supports the vision of the Committee, set forth in the Strategic Planning Document published in 1995, and the Administration's National transportation goals:

"The Committee's vision is of a sustainable and seamless intermodal transportation system that effectively ties America together and links it to the world. This system will help citizens and businesses satisfy their needs by providing efficient, safe, secure, and environmentally friendly transportation of people and goods. It will result from a strengthened partnership among government, academia, and the private sector focused on effective management and renewal of existing infrastructure, strategic deployment of new technologies and infrastructure, and on R&D which supports each of these."

Based on its consideration of likely trends through the year 2020, the NSTC CTRD has defined five strategic goals for transportation to ensure progress toward this vision, and identified potential measures of overall progress toward those goals. These are summarized

below in Table I-1, and discussed at greater length in Section II of this report, which also addresses the evolutionary nature of the development of such measures.

<u>Strategic Goal</u>	<u>Outcome Measure</u>
Provide a safer transportation system.	Level of reduction in transportation-related fatalities, injuries, and property losses.
Achieve a high level of transportation system security.	Level of public trust and confidence in the security of the Nation's transportation network as determined through national surveys. ¹
Improve environmental quality and energy efficiency.	Number of major areas not now attaining legislatively-mandated air quality standards that reach these air quality goals by 2020. ²
Foster economic growth and productivity through global passenger and freight services.	Level of cost-effective passenger and freight throughput. ³
Ensure improved access to and increased mobility on the Nation's transportation system.	Degree of increased and enhanced access and mobility of the elderly, the poor, and other transportation-disadvantaged populations.

Table I-1. National Strategic Goals and Measures for Transportation

I.c. Conceptual Approach to Transportation Research and Development

Comprehensive and well-founded planning is essential for 21st century transportation challenges and opportunities to be met. A carefully structured framework and process are

¹Additional measures under consideration include: number of security incidents and threats by type of facility; level of transportation-related crime affecting goods movement and/or business and personal travel.

²Additional environmental indicators applicable to transportation are also under development. Examples include: states reporting highway-related wetlands losses; states reporting road salting as a significant source of groundwater contamination; and percent of population exposed to transportation-related noise associated with health and other effects.

³Additional measures under consideration in this area (see Section II, Chapter 6) include city-specific total hours of delay and/or speed distributions on different highway categories. Economic measures under consideration include volume-specific national passenger and freight transportation expenditures.

particularly necessary so that limited Federal research, development, and education and training resources can be managed and leveraged to achieve a strong and balanced overall program.

The NSTC CTRD is a central part of this planning process. Created in 1994, the Committee's role is to ensure that the Federal investment in transportation R&D is (1) coordinated to ensure efficient use of Federal funds aimed at this mission; (2) focused on projects identified by users, industry, and other stakeholders as being the most critical to achieving success in agencies' missions; and (3) limited to areas where it is clear that major public benefits can only be achieved through cost-shared Federal research.

Through its initial planning efforts (with major involvement of the transportation community) the Committee has completed the first *Transportation Science and Technology Strategy* to help Congress, the White House, and Federal agency heads to establish National transportation R&D priorities and coordinated research activities in support of National goals for the transportation system. The Strategy is based on the results of numerous outreach events, environmental scans, and an analysis of the transportation system's current and future strengths, weaknesses, opportunities, and threats.

The Strategy has a four-tiered approach to the shaping and implementation of surface transportation research, ultimately involving stakeholders at every stage in the process:

- **Strategic Planning and Assessment** to establish a research framework that embodies *National Goals* and establishes associated measures of transportation system performance by which research projects can be selected and evaluated.
- **Strategic Partnership Initiatives**-- leveraged, multi-agency, and public-private in nature--that focus on the aggressive exploitation of rapidly evolving technological opportunities and the introduction of innovative equipment and operations into the transportation enterprise.
- **Enabling Research** in areas that support long-term transportation goals and contribute to long-term innovation and offer significant impacts affecting many modes of transportation, but have benefits too diffuse, uncertain, or far in the future to motivate sufficient private sector investment.



Figure I-1. Strategic Planning Approach

- ***Transportation Education and Training*** to assure the continued availability—in a time of rapid technical, demographic and other changes—of the highly-qualified transportation professionals and workers upon whom depends the design, construction, operation and maintenance of the Nation's transportation system, ultimately determining its safety and performance.

I.d. Relationship between NSTC Strategy and this Plan, and Vision for the Future

This *Surface Transportation Research and Development Plan* addresses each of the above tiers in detail, and also presents the long-term view of the Department's strategy for surface transportation R&D. Program-level plans addressing funding and staffing levels, and progress milestones will be developed through a strategic R&D planning process conducted in each of the Department's operating administrations. This process will be coordinated within DOT through its Research and Technology Coordinating Council. Although this process has already involved a wide range of ongoing interagency coordination activities, the transition toward the more exhaustive and intensive collaboration is yet to come. It is anticipated that the Department's program-level R&D plans will be structured based on the broad directions established in the *NSTC Transportation Science and Technology Strategy* beginning in FY 1999.

The central finding of the Council on Competitiveness, in its April 1996 report *Endless Frontier, Limited Resources: U.S. R&D Policy for Competitiveness*, is that "R&D partnerships hold the key to meeting the challenges of transition that our Nation faces." This appears to be particularly true in the transportation enterprise. Because of the range of stakeholders in transportation, the successful creation of such partnerships among the private, public, and academic sectors will require more extensive, and earlier, involvement of these groups in the strategic planning of transportation research.

The *Transportation Science and Technology Strategy* completed recently by the NSTC represents a significant step in that direction. It establishes a research agenda for the Federal government which will form the basis for program-specific R&D plans developed by individual agencies, including those within DOT, for FY 1999 and beyond. There was substantial input from industry and academia, as well as from a few levels of government. However, it is now important to carry the process of coordinating the broad directions to the program level in a coherent, coordinated strategic planning framework.

Existing program-level plans, as evidenced by the third section of this *Surface Transportation Research and Development Plan*, were established according to goals not fully accepted by this Strategy. Nonetheless, ongoing coordination processes will be effective in refocusing the

relationships with the agenda of the Strategy. These relationships are illustrated in the first chapter of Section III.

The Department's vision is that the Administration's interagency Strategy will become the cornerstone of an expanded and integrated strategic planning process in which industry, government, and academia all participate actively. Ultimately, the Strategy, and plans for its implementation and assessment, would be documented through four key components:

- **A National *Transportation Science and Technology Strategy***—A strategy for transportation-related research throughout industry, government, and academia, developed through cooperative participation of all of these stakeholders.
- **A National *Transportation Research and Development Plan***--A program-level plan for implementation of the Strategy, identifying specific private/public/academic partnerships and enabling research activities, developed as above.
- **A DOT *Transportation Research and Development Plan***--A program-level plan for R&D to be conducted by all (including nonsurface) DOT operating administrations, identifying specific activities in support of partnerships and enabling research needs, developed on a coordinated but agency-specific basis.
- **An Assessment of the Impact of R&D Investments at All Levels**--An ongoing assessment of the degree to which transportation R&D programs are leading to the achievement of National goals for the transportation system.

Completion of the NSTC *Transportation Science and Technology Strategy* represents an initial step toward an expanded and integrated strategic planning process. This *Surface Transportation Research and Development Plan* is focused on surface transportation, and is, on a program-specific level, structured in terms of FY 1998 budget plans that preceded this Strategy. The Department expects to move subsequent editions of this report toward this broader vision by expanding the report to cover all transportation modes, and structuring program-specific budget plans in terms of the Strategy and its successors.

I.e. Authority

This is the fourth in a series of congressionally required plans submitted by the Secretary of Transportation to the Congress pursuant to Section 6009(b) of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The third edition of the plan was submitted in September 1996.

I.f. Plan Objectives and Congressional Mandate

ISTEA requires that an integrated National surface transportation research and development (R&D) plan be developed that focuses on surface transportation systems needed for the next decade. The congressionally mandated objectives of the plan are: 1) to develop a range of technologies needed to produce convenient, safe, and affordable modes of surface transportation to be available for public use beginning in the mid-1990's; and 2) to maintain a long-term advanced research and development program in order to provide for the next generation of surface transportation systems. In addition, ISTEA requires that the plan include the following:

"(A) Details of the Department's surface transportation research and development programs, including appropriate funding levels and a schedule with milestones, preliminary cost estimates, appropriate work scopes, personnel requirements, and estimated costs and goals for the next three years for each area of research and development.

(B) A ten-year projection of long-term programs in surface transportation research and development and recommendations of the Research and Development Coordinating Council of the Department of Transportation and the plan of the National Council on Surface Transportation Research.

(C) Recommendations on changes needed to assure that Federal, State, and local contracting procedures encourage the adoption of advanced technologies developed as a consequence of the research programs in this Act [ISTEA]."

I.g. Scope

Surface transportation R&D, broadly defined, is conducted by a number of Federal organizations (e.g., DoD, DOT, EPA, DOE), by State and local government agencies, by academic institutions, and by the private sector. Within that context, this plan focuses on the surface transportation research underway or planned within the six DOT administrations with direct responsibility for surface transportation:

- Federal Highway Administration (FHWA)
- National Highway Traffic Safety Administration (NHTSA)
- Federal Railroad Administration (FRA)
- Maritime Administration (MARAD)
- Federal Transit Administration (FTA)
- Research and Special Programs Administration (RSPA).

Other departmental research, including that conducted by the Federal Aviation Administration's (FAA), the U.S. Coast Guard (USCG), and the Office of the Secretary of

Transportation (OST) is addressed when it correlates specifically to research being conducted on surface transportation issues. In particular, FAA's Aviation Human Factors Program, discussed briefly in Section III, is specifically related to the human factors programs being conducted in FRA, NHTSA, FHWA, FTA, MARAD, and USCG. Other FAA research and technology programs are also related. The Aviation Security program remains a top priority, and the Airport Pavements program continues efforts to improve airport pavement in order to accommodate the next generation of very large aircraft. These efforts are detailed in FAA's 1997 Plan for Research, Engineering, and Development published in January 1997. The *Surface Transportation Research and Development Plan* also discusses activities of the Bureau of Transportation Statistics (BTS), as these have a very direct role in supporting the Department's strategic planning and system assessment efforts. As mentioned above, it is hoped that this report can be expanded in the future to encompass all of the Department's transportation research, not just the surface elements.

The near-term section of this plan focuses on research underway or planned in FY 1997, 1998, and 1999. In response to the directive in ISTEA, the plan provides details of the surface transportation R&D programs, including funding levels, milestones, and personnel requirements. The plan's long-term outlook outlines a conceptual approach to transportation R&D that includes ongoing strategic planning; priority partnership R&D initiatives, ten of which address surface transportation; a set of six broad-based enabling long-term research areas critical to long-term progress in transportation; education and training to maintain a skilled transportation workforce in the future; and the measurement of progress toward strategic goals and of performance of specific programs. The plan's final chapter on contracting provides an overview of current contracting practices, summaries of recent changes in legislation and regulations, and brief descriptions of relevant contracting studies and task force efforts that are currently in progress or have been completed since the last edition of this plan.

This edition of the R&D plan, like the previous edition, emphasizes a strategic vision for surface transportation R&D activities. As in the three previous editions, the Department has relied extensively on its ongoing outreach activities in establishing R&D priorities. For this edition of the plan, comments specific to the plan have been obtained through a number of processes discussed in Section II. The Department has supplemented its ongoing outreach efforts through an intensive solicitation of outside input specifically related to this report, including first-ever publication on the Internet.

I.h. Plan Organization

This plan is divided into the following sections related to surface transportation R&D:

- *Section II* presents a strategic vision and direction for surface transportation, establishes a context for that vision by examining a number of key future trends and issues, and presents a range of specific initiatives and long-term enabling research areas relevant to

surface transportation. The plan emphasizes long-term integration and coordination of departmental R&D efforts in implementing these core endeavors, as well as partnering to leverage scarce R&D resources in the private, public, and academic sectors. This section also discusses the development of performance measures as a necessary underpinning of ongoing strategic planning for effective resource utilization.

- *Section III* outlines the Department's near-term (FY 1997-1999) surface transportation research program in five major areas: (1) physical infrastructure; (2) information infrastructure; (3) next-generation vehicles and fuels; (4) human-centered transportation systems, and (5) intermodal systems assessment, design, planning, management, and operations. This Section also discusses related university and cooperative research activities, and gives an overview of administrative and facility planning associated with these programs. Relationships between the Department's near-term R&D programs and the partnership initiatives and enabling research areas identified in Section II are explored in the first chapter of Section III.
- *Section IV* discusses contracting procedures affecting the Department and its grantees.

1.1. Changes From the Last Edition

As noted above, this edition, like the last, presents a long-term vision for surface transportation and a strategic plan for long-term R&D activities in one section, and an overview of near-term activities in a following section. This fourth edition of the report, drawing heavily upon the recently completed NSTC Transportation Committee *Transportation Science and Technology Strategy*, establishes a tiered structure for transportation R&D, consisting of the four components discussed above. This structure, presented in the second section of the report, moves away from a strict distinction between near- and long-term R&D, and toward a more focused set of long-term research areas, and a set of strategic initiatives which could be pursued immediately, and are more pointedly oriented toward private/public partnering.

The third section, as in the previous edition, describes the Department's near-term R&D programs, and consists of eight chapters that rely heavily on the framework established by the Transportation Committee of the National Science and Technology Council (NSTC). Although most of the content of this section is similar in structure, scope, and detail to that of the last edition, the third chapter, which addresses information infrastructure R&D, has been expanded to reflect the finer details of the ITS program, as well as the distribution of responsibility within DOT operating administrations.

SECTION II

STRATEGIC PLAN FOR SURFACE TRANSPORTATION RESEARCH AND DEVELOPMENT

1982

1982-1983
1983-1984

CHAPTER 1

TRANSPORTATION IN 2020

Worldwide, a number of forces are converging to shape the direction of transportation over the next two decades. Understanding these changes is critical to formulating a vision and goals for transportation. Key among these global changes are significant shifts in demographics, accelerated economic growth and globalization, growing urbanization and motorization, increasing concerns for safety and security, and changing technological trends.

As we enter the 21st century, these global issues and trends will present transportation decision makers and researchers with a dilemma: how to meet the increased demand for transportation while also addressing the sometimes conflicting values of safety, security, economic productivity, environmental quality, energy efficiency, and accessibility.

In the past, changing transportation needs have typically been met through innovations in three areas: transportation vehicles; the physical infrastructure that supports their use; and the people who design, build, operate, and maintain the vehicles and infrastructure, and who plan and manage the transportation enterprise. More and more, the burgeoning demands on the transportation system will be met through a fourth means: the development and deployment of an information infrastructure that underlies transportation's physical infrastructure. In fact, one component of any strategy to meet transportation needs will in fact be a stimulation of alternatives to physical travel, where such a substitution is appropriate and effective.

Each of the four areas of innovation will be key to meeting the emerging global issues and trends discussed below and are the foundation for the planning process, partnership initiatives, enabling research, and education and training efforts that compose the above-mentioned NSTC Strategy.

II.1.a. Changing Demographics

Two major demographic changes will influence the scope and character of world transportation demand in the 21st century: population growth and the aging of the population in the industrialized world. Over the next 25 years, world population is projected to grow from its present 5.5 billion to 8.5 billion people. By far, most of this growth will be in the cities of the developing world. The increased demand for transportation for this growing population will require the expansion of existing infrastructure—highways and transit systems—and perhaps new transportation alternatives. At the same time, in the U.S. and many other developed countries, the geographic and financial resources available to build new physical infrastructure is sufficiently limited that an emphasis on efficient management and operation of existing systems, which can be facilitated through the judicious application of information technology, is vital.

While industrialized countries' populations will stabilize and perhaps even decline, there will be further aging of these populations. Today, over 12 percent of the United States' and 14 percent of Europe's population is over 65. By 2020, over 20 percent of the population in the industrialized world will be this age.

The United States alone will experience far greater growth in its elder population: an estimated 53 million people will be over 65 in the U.S. by 2020. This dramatic growth in the aging population will necessitate new approaches to transportation and mobility, among them changes in traditional transit services, transportation infrastructure, and vehicles. At the same time that this is taking place, other demographic shifts with similarly important implications for transportation demand will continue in the U.S.

For example, the increased presence of women in the workforce, which will be further encouraged by welfare reform, could further increase dependence upon private vehicles. Salaried women, more often than their male peers, shoulder the bulk of the responsibility for the day-to-day management of U.S. households, which often translates into a chained sequence of related trips to and from destinations such as workplaces, day care centers, and grocery stores.

II.1.b. The Information Technology Revolution

With rapidly increasing access to and use of personal computing technology, both at home and work, the steep rise in use of the Internet, and growth in services which permit easy access to the vast array of available electronic information, Americans are rapidly becoming accustomed to being "plugged in" in real-time. This is also leading to the expectation of access to real-time information on transportation mode choices and traffic conditions. It is also leading to changes in travel patterns, as more workers can conduct business at home or from locations other than their office, including their car or on other modes of transportation.

Historically, physical mobility has been a primary means through which people have gained access, and that mobility has been distributed primarily based on financial means. However, the creation, distribution, and use of information has become ever more central to the life of modern societies, and access to services and even employment can be increasingly be achieved through information transfer, rather than physical mobility. Of course, physical mobility will continue to be a prerequisite for many jobs, services, and leisure activities, and a variety of effects associated with telecommunications advances could stimulate travel and transportation demand. Information technology will, therefore, play a prominent role both in shaping future transportation demands, and in enabling new management and operational practices that make it easier to meet those demands in an era of constrained expansion of physical infrastructure.

II.1.c. Economic Growth and Globalization

Although there continues to be incredible poverty throughout the world, economic growth in selected regions is providing a base for the development of newly emerging upper and middle income classes. Gross domestic product per capita is steadily increasing in many countries. This trend is quite dramatic in newly industrialized countries, particularly in several Pacific Rim nations. More people have more disposable income, after paying for food, shelter, and other necessities, than in any other period in human history. This income, combined with the influence of the mass media and telecommunications, will continue to create a booming travel and tourism market. As world tourism becomes an increasing share of transportation demand, the capacity of many nations' surface and air transportation infrastructures will be strained.

In parallel with growth in international tourism and travel will be corresponding increases in international goods movement. Low-cost communication and transportation networks have already resulted in a global manufacturing and marketing enterprise. In this interdependent world economy, continued growth in international trade will increase the demand for freight transportation facilities and place increasingly stringent cost and reliability requirements on transportation networks, particularly intraregional networks that link increasingly dispersed networks of interconnected businesses. Coupled with this, use of information networks for "virtual" conduct of business may reduce demands for some kinds of personal travel, while simultaneously increasing demands for other kinds of passenger and freight services.

II.1.d. Urbanization and Motorization

About 45 percent of the world population currently are urban dwellers. By 2025, more than 60 percent of the projected 8.5 billion people in the world will be living in cities—many of them in megacities with populations of 10 million or more. Together with economic development, growth in the world's urban areas has led to a dramatic increase in the number of motor vehicles over the past 25 years. In 1970, there were 246 million vehicles registered in the world, 44 percent of them in the United States. By 1992, the world had 614 million vehicles, two and a half times the number in 1970, with only 31 percent in this country. In fact, the global fleet has been growing linearly since 1970, with each year bringing an additional 16 million vehicles. Should this trend continue, there would be more than 1.1 billion vehicles in the world fleet by 2025. Along with the world's growing reliance on motor vehicles has come a concomitant increase in environmental and energy impacts—global carbon emissions, petroleum consumption, air pollution, and congestion. Moreover, coupled with high population growth rates and a growing vehicle fleet, sprawling urban development is a major cause of pollution, congestion, and poverty in many of the world's cities.

In the United States, suburban sprawl has led to spatial disparities in the location of employment centers and concentrations of urban poor, who are now required to find work under the recently enacted welfare reform law. The internal migration of the population,

combined with migration from abroad and with the rapid suburbanization of homes and jobs, have been linked to:

- substantial population and employment growth in the west and south;
- concentrations of migrants from abroad in a limited number of states;
- major growth in suburb-to-suburb commutes;
- major growth in reverse (i.e., urban core to suburb) commutes; and
- increased distances between home and all trip destinations.

These patterns, which vary in specific manifestation from one region to the next, have profound implications. Employees who both work and live in low density places have scattered travel patterns--they do not travel along highly concentrated corridors, and they have few alternatives to the private car when they travel. Employees who live in the core of metropolitan areas but work in the suburbs also create nontraditional commutes and may have limited travel options. Overall, these population and land use trends accelerate the travel patterns linked to the growth of a service-based economy, leading to longer work and nonwork trips, more scattered origins and destinations, and greater dependence on single-occupancy private vehicles.

II.1.e. Safety and Security of the Global Transportation System

Over the next two decades, continued growth in world transportation demand will lead to heightened concerns for transportation safety and security. For example, along with growth in automobile use will come the potential for a dramatic increase in automobile-related deaths and injuries. This is particularly true for many countries in the developing world, where the number of motor vehicles is growing far faster than the physical, legal, and institutional infrastructures needed to accommodate them. From 1968 to 1985, automobile fatalities increased by more than 300 percent in eight African countries and by almost 200 percent in six Asian nations. Even in the more industrialized countries, where safety records are typically good by historical standards, the private automobile will continue to present safety risks. Still other concerns will arise from the growth of air transportation and its increasing use for international travel. Greater demand for air travel will place additional stress on an already overburdened aviation system. As countries seek to accommodate demand by moving toward "free flight" (described further in Section II.a.3.iii) and a global infrastructure for air traffic management, questions may arise concerning the reliance on satellite and digital technologies, the increasing dependence on complex software-based aids and systems, and the need for global standards and interoperability. Moreover, the troubled state of the world and the attractiveness of aviation as a terrorist target make it likely that aviation security, as well as security in other modes of transportation, will be a major area of concern well into the 21st century.

II.1.f. Technological Trends

One clear reality of the late 20th century is the power of technology and the advances that can be achieved when it is applied in the right way, to the right problems, and in concert with more effective institutional relationships and a better understanding of the social forces that shape travel behavior, land use, and transportation needs. The magnitude and pace of improvements in the next century will depend on the investment of energy, imagination, and public and private resources made at the close of the 20th century. By 2020, advances in computer, information, and communications technologies will have dramatically changed ways of organizing and managing transportation and business activities. There will be an increasing number of potential alternatives for various transportation functions, each offering real benefits. For example, the transportation vehicles manufactured 25 years hence can be expected to offer dramatic advances in sustainability, performance, and cost, based on refinement and innovation affecting almost every component. The Administration's Partnership for a New Generation of Vehicles (PNGV) will yield significant improvements leading to lighter weight, lower cost materials, improved emission characteristics, and greatly lessened petroleum requirements. In general, technological advances will be critical factors in ensuring that the overall transportation system is brought to its full potential in terms of life-cycle economics, energy efficiency, and minimal adverse societal impacts.

The Department has conducted an environmental scan of the key technological trends which are projected for the next five to ten years, and has examined their potential impacts on the National transportation system and DOT. The general findings of this exercise are summarized below in Table II-1-1.

Trend	Impact on DOT
<p>Information: Accelerated application of advanced electronics, information systems, and control systems to transportation. Over the next five years, these information-related technologies will enable the collection, management, integration, and distribution of transportation-related information in less time (< 1/100 current), with better fidelity (> 10 to 100 times more information), and broader applications. The Nation's transportation system will enter the information age.</p>	<p>Increasing role for DOT to set standards and guide the development of international standards for information system interfaces and electronic, safety, security, and communications systems.</p> <p>Increasing pressure to allow flexibility in the use of grant funds for installation or retrofit of electronic and information technologies in current and future systems.</p> <p>Sharing information on approaches for integrating and applying security measures on a multi-modal basis, and for maintaining closer operational links with law enforcement officials, fire departments, hospital units and the military is imperative.</p> <p>Will enable concurrent Federal, regional, state, and local planning, and national-level traffic management and infrastructure monitoring.</p>
<p>Materials: Stronger, lighter, and environmentally friendly advanced composites and materials will revolutionize the construction, maintenance, and repair of transportation guideways, vehicles, and systems.</p>	<p>Need to maintain emphasis on development and application of advanced materials established in DOT <i>Strategic Plan</i> is imperative. The benefits to transportation in the materials area are long-term. Research must be sustained in spite of increasing focus on near-term results from R&D.</p> <p>Need to continue leverage and apply advanced materials developed for military or aviation use in other areas of transportation.</p> <p>Need to incentivize the use of new structural techniques and materials in transportation systems.</p> <p>Need funding for the development of new and innovative materials with multi-modal applicability.</p>
<p>Energy and Environmental Technologies: New power systems, combined with lighter structures, will improve the energy efficiency and environmental compatibility of transportation vehicles. The first "sustainable" transportation systems will begin to emerge.</p>	<p>Improvements may generate pressure from the public and environmental groups to revisit and tighten some emissions and fuel economy standards.</p>

<p>Human Factors: Increasing knowledge and acceptance of "human-centered" system design and technology integration concepts will promote safer and more user-friendly transportation services, which are more accessible to mobility-limited users.</p>	<p>Coupled with increases in the population of elderly persons, the entire area of specialized or personalized transportation will have to receive greater emphasis.</p> <p>To assure continuing application of military and aerospace applications of human factors discoveries, closer working relationships among DOT, DOD, and NASA will be necessary.</p> <p>Standards for operator training will have to be reassessed on a multi-modal basis as increasing application of improved simulators to the function takes place.</p> <p>Modeling of individual human performance and reactions, along with vehicle performance simulations, will enable "virtual" testing and training.</p>
<p>Industrial Design: Advanced three-dimensional models and simulations will foster new vehicle design concepts, container designs, terminal management approaches, and traffic management to promote intermodal operations and facilitate transfers between the modal elements of the transportation system.</p>	<p>DOT will need advanced planning and policy formulation, simulation, and modeling tools to represent intermodal interactions well.</p> <p>Increasing pressure for DOT to take a role in the standardization of containers, data exchange formats, etc., to facilitate intermodal trade.</p> <p>More sophisticated and faster screening techniques will be needed to monitor system security while increasing passenger and freight throughput.</p> <p>DOT will have to maintain a workforce which is technically qualified over a broader range of management and technical disciplines.</p>

Table II-1-1. General Technology Trends, Impacts on DOT

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CHAPTER 2

STRATEGIC GOALS AND THE ROLE OF RESEARCH

II.2.a. National Goals for Transportation

Considering the likely 2020 future, the NSTC Committee on Transportation R&D has defined a set of strategic goals and measures that encompass safety, security, environmental quality, energy efficiency, economic productivity, accessibility, and mobility. Investment in transportation research, technology, and education can significantly improve the probability of attaining these goals. These goals, summarized above in Table I-1, are discussed at greater length below.

The White House and Federal agencies, in conjunction with the National Research Council (NRC), have been working to identify strategic goals and appropriate measures to determine the impact of Government research and technology investments on the performance of the national transportation system. For example, over the past two years the NRC has conducted roundtables for key members of the Federal transportation enterprise and supported the definition of National transportation goals and strategic partnerships and measures.

What follows is a more detailed discussion of the five major transportation goals upon which both the NSTC *Transportation Science and Technology Strategy* and this plan are based. Potential measures of success and program performance are discussed below in Chapter 6.

II.2.a.i. Transportation Safety

A core transportation objective is to reduce deaths and injuries and to minimize the dangers associated with all modes of transportation. Worldwide, 250,000 people a year are killed in transportation accidents and over 10 million injured. The fatality and injury rates in developing countries are 3 to 4 times those of the U.S. As the number of motor vehicles in the developing world increases, world fatalities may reach 1 million per year, with 40 to 50 million injuries. Another consequence of growing demand will be a doubling of the world civil aviation fleet. At current accident rates, a doubling of civil aviation traffic implies more than 4,500 annual aviation-related fatalities worldwide by 2025.

Today, more than 40,000 people are killed on our Nation's highways each year—the equivalent of a DC-9 crashing and killing all of its occupants every day of the year. Many fatalities are caused by errors in driver judgement due to inadequate or untimely information necessary to avoid a collision. Human error is the most pervasive fundamental problem and the greatest limitation to improving transportation safety and efficiency. Thus, a major focus of the transportation enterprise's R&D activity is to understand the causes of, and determine the means to eliminate, human error as it relates to the safe operation of vehicles in all modes

of transportation. Increasingly, transportation is experiencing a paradigm shift toward active accident prevention as a vital complement to passive prevention measures (e.g., highway design) and occupant protection.

Although these activities are directed at the most important root cause of accidents, it would be unrealistic to expect that they could prevent all accidents. Research in the areas of fault tolerance and crashworthiness have been important to reducing the damage caused by accidents that do occur, and a continued commitment to these activities will be of vital importance now and in the future. For example, NHTSA is currently initiating research activities to improve the characterization of new structural materials that may be used in next-generation vehicles, which will help to ensure the proper design of applicable safety standards. FRA and FTA have nearly completed a five-year plan for a joint Commuter Rail Safety Research Program, which would address the following key safety elements: structural integrity and passenger protection; suspension system performance; wheels and other components; signal systems and train control; grade crossing hazards; human factors; fire safety; and emergency preparedness.

These and other major issues ensure that safety concerns will continue to be integral to many transportation R&D initiatives.

II.2.a.ii. Transportation Security

Security is a key element in retaining the public's trust and confidence in the global transportation system. Yet, in the last few decades, the threat of hijacking and deliberate sabotage has become real and highly visible worldwide. In the aviation arena, for example, it is an enormous challenge to keep all weapons and explosive materials off an airplane carrying several hundred people and their highly varied luggage. At the same time, recent plots or actual attacks have been made against railroad, mass transit, and highway targets, both domestically and internationally.

The security of transportation's information infrastructure is another area of growing concern. A transportation system permeated with information technologies could prove highly vulnerable to malicious and terrorist attacks focused on introduction of false information into the system or interference with computer and communication system operation. As transportation systems become increasingly integrated with information systems, the potential increases for widespread system disruption and personal injury as a result of such security breaches.

II.2.a.iii. Environmental Quality and Energy Efficiency

Environmental and energy concerns affect transportation system development worldwide. Everywhere, transportation is becoming the focus of concerns about fossil fuel consumption, global warming, and air quality. For instance, current scenarios estimate that the world demand for petroleum, by far the primary fuel source for transportation, could double to as

much as 150 million barrels per day. Critical fuel supplies to a nation could be disrupted over the short or long term by local conflicts, natural disasters, economic downturns, or conscious political decisions.

As cities grow and the demand for transportation increases, the resulting growth in transportation activity places nearly unsustainable pressure on land use, traffic congestion, and air and water quality. The emissions caused by petroleum consumption contribute to both human health problems and the possibility of global climate change. Although very important progress has been made in reducing emission rates over the past 25 years through the application of technologies such as 3-way catalytic converters and closed-loop fuel control systems, cars, trucks, and other vehicles are still major sources of carbon monoxide, volatile organic compounds, nitrogen oxides, and fine particulate matter. Highways have been blamed for erosive and contaminated runoff and ruination of wetlands. At the same time, communities have formed coalitions that vigorously protest the risks of hazardous materials transport, such as oil spills, and the adverse impacts of transportation noise.

Combined with the dramatic forecasts for growth in world population and transportation demand, these issues have given environmental and energy concerns prominence on the national agenda at the same time that physical and financial constraints are limiting expansion of existing transportation infrastructure to meet demand. Potential strategies to reduce travel demand face tremendous challenges, and it is increasingly apparent that intelligent management and operation of transportation systems will be critical to meeting these wide-ranging and often conflicting demands.

II.2.a.iv. Economic Growth and Productivity

Trade and tourism are areas of great significance to the world's economy. Tourism alone may be the single biggest economic activity in the world today, accounting for over one-tenth of the total global gross product. And, as population and disposable income both grow, a dramatic increase in international passenger travel can be anticipated. In particular, this trend will stimulate growth in air travel, and thus the need for user-preferred routes and schedules, new and expanded airport facilities, and associated transportation connections throughout the world.

Such growth also will stimulate the demand for finished goods, which in turn will expand growth in freight transportation services worldwide. Oceanborne trade is expected to increase at an average rate of 4.5 percent between 1994 and 2005. Just-in-time goods movement—with the goal of minimum inventories—is increasing both the number of trips made by parts suppliers and final assemblers' deliveries to purchasers, creating the need for more efficient and reliable freight movement through urban and suburban centers. At the same time, the shift of manufacturing to the developing world and the increasing "out-sourcing" of component and parts production will necessitate increased freight movements during the manufacturing process itself.

Transportation decision makers at all levels will need to respond rapidly to these demands for passenger and freight services. Yet, many local officials are not aware of the significance of these issues to their regions' economies or of the infrastructure and operational needs of these activities. If they are to consider the entire transportation system—including all modes and the connections among them, both locally and internationally—as well as alternatives to physical travel in making major transportation decisions, transportation officials will need better planning tools, information, and technologies to assess the impacts of such choices.

With today's highly competitive surface transportation enterprise and research, it would be very easy for the U.S. to become a Nation of technology importers and purchasers, rather than innovators and sellers. Both the *Transportation Science and Technology Strategy* and this *Surface Transportation Research and Development Plan*, consistent with the intent of ISTEA, emphasize opportunities for cooperation with industry and "strengthening the manufacturing capabilities of United States firms in order to produce products for surface transportation systems."

While looking toward long-term gains and technological advances, it is also critical to ensure continued attention to incrementally evolving customer needs and deployment opportunities. Established infrastructure and systems are such that applied research represents the majority of research needed to meet ongoing repair and restoration needs.

II.2.a.v. Accessibility and Mobility

The recent major growth in suburb-to-suburb commutes and "reverse" commuting (city center to suburb), new and decentralized employment locations, variable employment schedules, and the growing number of non-commute trips, particularly for women, create considerable challenges for fixed-route transit services and other alternatives to private automobile travel. The challenge for the transportation enterprise will be to manage limited resources effectively to provide access and mobility for all segments of the population.

Among the transportation enterprise's primary missions is to help local agencies provide essential, affordable transportation services to those who—because of age, disability, income, or personal preference—do not use an automobile. For example, estimates suggest that by the year 2020, one out of six members of the population will be over 65, with the fastest growing cohort those least likely to have easy access to automobile transportation—the population 85 and older. Likewise, children, as well as those of any age with physical disabilities have considerable mobility needs. Welfare reform places renewed emphasis on the importance of mobility for those attempting to access and retain employment but do not own an automobile. The spatial disparity of where new employment centers are located and where many of the poor live points to a serious mobility gap.

As is discussed in *II.1.b*, information technology will be an important factor in the evolution of future travel patterns, and will also play a critical role in the management and operation of transportation systems to meet future mobility requirements.

II.2.b. The Role of Research

The goals described above present the entire transportation enterprise with a challenge of great magnitude, particularly in a time of financial constraints, growing demand, and decentralization and devolution of transportation responsibilities. From the DOT perspective, there is an additional imperative to find more effective and less costly means of carrying out Federal operational and regulatory responsibilities. Research, and the innovation that it enables, will be a critical component in the National response to this challenge. The stimulation and fostering of innovative technologies and methods in transportation will thus be central to meeting national needs in the next century.

Fortunately, these challenges, and the associated necessity for continuing innovation, arise in an era richly endowed with a wide range of steadily-advancing technologies and tools that, effectively applied, have great promise for resolving current or anticipated problems. Innovation is seldom a smooth process, and realization of significant change in transportation systems—tightly linked to their environment and characterized by very long-lived infrastructure and vehicles—is complex and difficult. Research and development enables and stimulates innovation by the three both parallel and interconnected paths which are described below.

II.2.b.i. Development of New Technologies

Various modes of transportation have at times been revolutionized by the development of practical realizations of new technologies, such as the diesel locomotive and the jet engine. Major research efforts are currently under way to improve the fuel efficiency of personal motor vehicles and provide propulsion based on non-petroleum sources, such as electricity or alternative fuels, perhaps using advanced energy conversion technologies such as fuel cells. While rare, innovations yielding a quantum leap in economic efficiency, speed, or safety can transform the operations and role of affected transportation functions or modes, and dramatically change the performance of the entire system. New technologies may be essential to the solution of problems that would otherwise be intractable.

II.2.b.ii. Introduction of Existing Technologies into Transportation

The most common way in which R&D affects transportation lies in fostering and facilitating the adoption of technological advances in many fields into transportation applications. The use of information technology throughout the transportation enterprise is a particularly prominent current example, accompanied by application of improved materials in physical infrastructure as well as vehicles, nondestructive testing and inspection techniques, computer-aided design, and environmental engineering. Such technology is enabling the necessary transition from an

emphasis on building new physical infrastructure to meet transportation demand to an emphasis on effectively managing transportation systems to improve operational efficiency.

The introduction of innovative technologies itself raises many questions and challenges, including not only technical considerations but also uncertainties as to cost, effectiveness, and unintended consequences. Specific focused research initiatives are often essential to rapid and effective integration of available technologies in transportation functions.

II.2.b.iii. Increased Knowledge for Decisions and Actions

Whether innovation derives from new or existing technologies and operational concepts, a broad foundation of data, knowledge and understanding—concerning both transportation and the relevant technologies—is required for diagnosis of perceived transportation problems, identification of potential solutions or opportunities, comprehensive characterization and evaluation of alternatives (including their interaction with the people who use and operate them), and development of effective deployment strategies. Understanding of the interactions between humans and transportation systems, whether as users, operators or designers, is far from complete.

Transportation policies and decisions, whether public or private, must address a steadily widening range of considerations. Many stakeholders are involved, and the technical realities and uncertainties are generally complex. National policies can place heavy burdens on state and local agencies for planning and decision making in technically complicated areas. An example of ongoing research to ease this burden is the development of the sketch planning tool known as the ITS Deployment Assessment System. Without such tools and other needed information and data, it would be very difficult to meet these challenges.

II.2.c. Federal Involvement in Research and Development

The essence of Federal involvement in R&D was concisely stated in a 1995 report of the President's Council of Economic Advisors: "First, successful R&D in private companies depends on the flow of new ideas and trained people stemming from basic research and pre-commercial R&D. Federal support of these activities is vital. Second, the Federal government sponsors much applied research to improve its own capabilities in such areas as National security, health, and transportation." The nonprofit, nonpartisan Council on Competitiveness echoed this theme: "The Federal government must meet its long-standing obligation to stimulate civilian research."

With respect to transportation, this obligation takes the form of Federal research and technology initiatives, increasingly conducted in partnership with the private sector and academia, to stimulate innovation across the transportation enterprise. Although development of advanced transportation technology and improved operations is largely the responsibility of the private sector, focused federal investment in research, development, test, evaluation, and

technology dissemination can have great impact in the many areas in which market-driven R&D efforts are impeded by technological and other uncertainties as well as strong institutional impediments. The basic criteria applied are that the research must support long-term National goals, but with benefits too widespread, uncertain or distant to motivate private sector firms to invest independently. In addition, the largely non-Federal nature of the transportation sector mandates that R&D be conducted in collaboration with the firms who will ultimately design and manufacture products for the marketplace, the organizations that will operate and maintain the resulting systems, and the shippers and passengers who will use them.

Federal R&D is also called for where it is necessary to support the efficient performance of agency mission responsibilities, such as operation of federally-provided transportation-related services, guiding of public investment in the transportation system, and regulation of transportation safety and security.

II.2.d. National Transportation Science and Technology Strategy

Careful planning is essential for managing and leveraging limited Federal research, development, and education and training resources to meet 21st century transportation challenges and opportunities.

The NSTC Coordinating Committee on Transportation R&D (CTRD) was created in 1994 to ensure that the Federal investment in transportation R&D is (1) coordinated to ensure efficient use of Federal funds aimed at this mission; (2) focused on projects identified by users, industry, and other stakeholders as being the most critical to achieving success in agencies' missions; and (3) limited to areas where it is clear that major public benefits can only be achieved through cost-shared Federal research.

Through its initial planning efforts—with major involvement of the transportation community—the Committee has completed the first *Transportation Science and Technology Strategy* to help Congress, the White House, and Federal agency heads to establish National transportation R&D priorities and coordinated research activities. The Strategy is based on the results of numerous outreach events, environmental scans, and an analysis of the transportation system's current and future strengths, weaknesses, opportunities, and threats. The Strategy provides a framework for National partnership initiatives, enabling research, and education and training necessary to achieve National transportation goals. The vision, goals and conceptual approach that underlie the Strategy are presented in Section I of this plan, which highlights those elements that focus on the surface transportation system. As described in Section I.c, the Strategy has four components: (1) Strategic Planning and Assessment; (2) Strategic Partnership Initiatives; (3) Enabling Research; and (4) Transportation Education and Training.

II.2.d.i. Strategic Planning And Assessment

The institutionalization of a continuing transportation R&D strategic planning and assessment process will enable policy makers and implementers to adjust the allocation of scarce national R&D and other resources to meet changing requirements. This ongoing process, involving the establishment of a broad consensus among all levels of government, industry, and academia, will (1) establish and assess transportation goals in accord with a changing external environment; (2) identify strategic technology partnerships to support transportation goals; (3) identify a long-term enabling research agenda to support future transportation goals; and (4) develop measures of progress against national goals to evaluate the impact of Federal R&D investments. Outreach to leaders in industry, state and local government, academia, the research community, and other stakeholders has allowed the Federal Government to gather facts and analyze trends that give an objective picture of where we stand in the transportation "world," and of the external and internal pressures and factors likely to affect our future.

As observed during the March 1995 TRB/NSTC Forum on Future Directions in Transportation R&D, technological integration is needed at all levels to rectify current inadequacies in the following areas:

System Assessment--There is a need for improved data, analyses, and assessments in all aspects of transportation system performance.

Policy Research--Although technology is also important in systems assessment, there are critical issues that are more institutional or policy oriented than technical.

Intermodal Research--Advances in the characterization and modeling of system operations will be required in order to take full advantage of the opportunities to improve system efficiencies through effective use of all modes.

As is discussed in detail in Chapter 6 of this section, this ongoing activity necessary for effective management of all subsequent components of the Strategy must be supported by effective performance measurement. Through its current interagency strategic planning processes, the Department is currently vigorously pursuing the identification of a wide range of performance measures that address the transportation system as a whole, specific transportation modes, progress toward ultimate societal goals, and the success of individual programs.

II.2.d.ii. Strategic Partnership Initiatives

The Strategy specifically proposes a set of 12 research initiatives to be pursued as partnerships among government, industry, and academia. Particularly in transportation, which is a very applied discipline, investments in basic science and research are often best undertaken in collaboration and the exchange of people and ideas among Federal agencies, state and local governments, private

companies, universities, public interest groups, and other stakeholders. Strategic partnerships can be an effective means to expedite the research process and speed the introduction of valuable innovations into transportation systems and operations. These initiatives do not address the entire body of research needed to ensure desired improvements in transportation, or to meet all basic DOT responsibilities. They represent unique opportunities for leveraging of scarce resources to achieve rapid gains in specific technical areas.

The twelve partnership initiatives are listed below and presented in detail in Chapter 3 of this section. The initiatives fall into three categories: (1) transportation information infrastructure; (2) next-generation vehicles; and (3) transportation physical infrastructure.

- *Transportation Information Infrastructure*
 - Smart Vehicles and Operators
 - National Intelligent Transportation Infrastructure
 - Next-Generation Global Air Transportation
 - Enhanced Transportation Weather Services
 - Enhanced Goods and Freight Movement at Domestic and Int'l Gateways
 - Accessibility for Aging and Transportation-Disadvantaged Populations
 - Local Environmental Assessment Systems
- *Next-Generation Vehicles*
 - Next-Generation Motor Vehicles and Ships
 - Aviation Safety Research Alliance
- *Transportation Physical Infrastructure*
 - Total Terminal Security
 - Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure
 - Environmental Sustainability of Transportation Systems

II.2.d.iii. Enabling Research

Transportation inherently is based upon the application of a wide range of scientific and engineering disciplines, some of which are specific to transportation, and some of which have broader applicability. Innovation in transportation therefore necessitates ongoing R&D focused on adaptation of more-generic technologies examination of aspects unique to transport functions. The societal benefits of innovation can often be widely dispersed or require a long time period for realization. Hence, economic, institutional and other constraints make research of this type unattractive for private investment. In these areas, Federal R&D is warranted, accomplished wherever possible in multi-agency collaborations. The NSTC Transportation S&T Strategy identifies six areas of long-term enabling research that are appropriate and promising in terms of

their potential contributions to transportation innovations. These are listed below and discussed in detail in Chapter 4 of this section.

- Human Performance and Behavior
- Advanced Materials
- Computer, Information, and Communication Systems
- Energy Conversion for Propulsion
- Sensing and Measurement

II.2.d.iv. Transportation Education and Training

The benefits from national investments in transportation, whether based on existing or innovative technologies, are dependent on the transportation professionals and workers responsible for the design, construction, operation, and maintenance of the overall system. In the case of new technologies or novel applications, it becomes all the more important to assure that an appropriately trained workforce, with sophisticated technical knowledge and a strong understanding of the societal context within which transportation functions. This area is not new to the Federal government, which has a long history of supporting education. Current DOT activities include the University Transportation Centers Program, the Eisenhower Fellowships, the Aviation Education Program, and the National Highway and National Transit Institutes. Transportation today is undergoing great change—experiencing advances in technology, undergoing organizational transformation, and continuing globalization along with the world economy. These changes require that the Department and partner agencies expand efforts that will enable current and future generations of transportation professionals and workers to meet the demands of the 21st century. The three focal points of support for education and training investment are noted below and discussed at length in Chapter 5 of this section.

- Introduction of Transportation Concepts: Elementary and Secondary Education
- Vocational and Technical Training
- Transportation Degree Programs: International and Multi-disciplinary
- Mid-Career Transportation Training

II.2.e. The R&D Role of the Department of Transportation

Innovation in transportation calls for a balanced and integrated approach that links parallel streams of research, development, test and demonstration, and implementation. This entire process must be based on a clear understanding of specific transportation objectives and institutional, regulatory, and economic constraints. The translation of a tested and proven advance into revenue service or operational improvements often necessitates a major investment in providing users with sufficiently convincing evidence of its performance and probable benefits and with the knowledge needed to apply the innovation effectively.

The Department sponsors a range of research and development activity to support fulfillment of its core responsibilities, which are as follows:

- Establishing standards for safety and other key aspects of the transportation system, facilitating deployment of safe and effective transportation equipment and systems.
- Distributing funds to state agencies, transportation providers, and other related institutions to plan, construct, and operate the transportation system.
- Interacting with other Federal agencies to carry out broader Federal mandates such as the Clean Air Act and National security policies.
- Providing law enforcement and traffic management systems for the Nation's airspace and waterways.

R&D is critical to the Department's ability to meet the multiple, and sometimes conflicting demands the Nation places on its transportation system, particularly in an era of scarce resources. As the national steward of the transportation system, the Department has a unique responsibility to work in partnerships with state agencies, transportation providers, and other related institutions to ensure that the Nation fully capitalizes on technological, operational, and institutional innovations.

CHAPTER 3

PRIORITY STRATEGIC PARTNERSHIPS

A wide range of transportation R&D is needed to support basic DOT responsibilities, such as the establishment and enforcement of safety regulations. Strategic plans for this research are established by each of the Department's operating administrations, which collaborate on an interagency basis through the Department's Research and Technology Coordinating Council, and with stakeholders through a range of processes, and participate jointly in the development of departmentwide strategic planning documents such as this *Surface Transportation Research and Development Plan*.

Improvement is highly desirable in many aspects of transportation, and interesting and attractive innovative technological and operational concepts abound. Without an ongoing commitment to transportation research and development, the Nation would risk a high level of importation of key technologies. It has been estimated that the global ITS market for surface transportation will be in the hundreds of billions of dollars by 2025. However, it is clear that Federal government research over the next ten years, both that addressing basic governmental responsibilities, and that designed to take advantage of new opportunities for improvement, must be conducted in a climate of severe fiscal restraint. Ongoing consideration of the broad transportation R&D context will be essential, and will encompass important activities throughout the Federal Government, academia, the States, and industry.

The second tier of the NSTC Science and Technology Strategy, and one of its critical elements, is the identification of research partnerships among government, industry, and academia. One of the tenets of the President's Committee of Advisors on Science and Technology is that the Nation can best profit from investments in basic science and research through partnerships and the exchange of people and ideas among Federal agencies, state and local governments, private companies, universities, public interest groups, and other stakeholders. For agencies with transportation R&D responsibilities, strategic partnerships can expedite the research process and speed the introduction of much-needed new technologies into transportation systems and operations. Based on broad public and private sector input, this Strategy identifies twelve partnership initiatives, ten of which address surface transportation, offering some of the greatest benefits for transportation. Chapter 6 of this Section addresses the importance of an ongoing process to measure the performance and benefits of these initiatives and the whole of transportation R&D, and to integrate this into an ongoing strategic planning process.

All of these initiatives build on recommendations from various outreach events and meet all of the criteria listed to the right. The role of the Federal government in planning the details of these initiatives, and in implementing those plans, will vary depending upon the nature of the initiative and the range of partners.

These initiatives do not cover the full scope of the Nation's long-term surface transportation needs and, in particular, do not address the full range of DOT responsibilities. They are not intended to do so. However, they will help to make important and visible progress toward the long-term the National goals for transportation identified above in Chapter 2, and reflect prioritization of activities and resources in an era of limited resources.

The initiatives fall into three overlapping and interrelated categories: (1) transportation information infrastructure; (2) next-generation vehicles, and (3) transportation physical infrastructure.

Criteria for Partnership Initiatives

- Addresses a real recognized need.
- Has a technology focus--ideally a self-contained, readily implemented piece of technology.
- Market for the technology-based improvement exists--if successful with the technology, could rely on existing market forces and the private sector for widespread implementation.
- Is a need for a Federal role, with benefits to the Nation as a whole--taxpayers, traveling public, industry; the initiative could not proceed in a timely fashion without Federal involvement, support, or coordination, but also requires private sector cooperation and participation.

• *Transportation Information Infrastructure*

Initiative #1: Smart Vehicle and Operators

Initiative #2: National Intelligent Transportation Infrastructure

Initiative #3: Next-Generation Global Air Transportation

Initiative #4: Enhanced Transportation Weather Services

Initiative #5: Enhanced Goods and Freight Movement at Domestic and International Gateways

Initiative #6: Accessibility for Aging and Transportation-Disadvantaged Populations

Initiative #7: Local Environmental Assessment Systems

- **Next-Generation Vehicles**

Initiative #8: Next-Generation Motor Vehicles and Ships

Initiative #9: Aviation Safety Research Alliance

- **Transportation Physical Infrastructure**

Initiative #10: Total Terminal Security

Initiative #11: Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure

Initiative #12: Environmental Sustainability of Transportation Systems

II.3.a. Transportation Information Infrastructure

II.3.a.i. Smart Vehicles and Operators

Initiative: Smart Vehicles and Operators.

Goal: Reduce the occurrence of accidents in all modes of transportation through an enhanced understanding of human performance and behavior; the application of human-centered technological aids and systems for accident avoidance; and the development of advanced materials and technologies for vehicle operator training.

Participants: DOT (FHWA, NHTSA, FAA, FTA, FRA, USCG, MARAD), DOC, and other Federal agencies; the technology community; vendors; states; associations of vehicle operators; transportation companies; and vehicle manufacturers.

Benefits: A safer highway, railroad, transit, and waterways system, with fewer deaths, injuries, suffering, and property loss, accompanied by a reduction in trauma injuries for the U.S. health care system; reduced transportation vehicle repair costs; and, potentially, reduced automobile insurance premiums.

The first priority in safety is prevention—stopping accidents before they occur. The great majority of transportation accidents involve at least some degree of operator error brought on by fatigue, inattention, or incapacitation. An appropriate response to these concerns can be

formulated only on the foundation of a solid understanding of human characteristics as they relate to vehicle operation.

Technical advances, particularly in information technologies, now offer many possibilities in terms of devices to warn operators of unsafe circumstances, or to suggest or even initiate corrective actions. The ITS program, for example, specifically includes elements intended to assure full exploitation of these opportunities. Additionally, innovative means of inspecting and monitoring the condition of vehicle and infrastructure components, periodically or while in operation, can make it possible to take corrective action before an accident occurs.

This partnership initiative incorporates a wide variety of R&D activities associated with accident avoidance. For conciseness, they are discussed here in three broad groups: human performance, accident avoidance technologies, and operator training and education.

Human Performance: Research directed toward better understanding of operator performance in transportation systems now offers great promise. As these results are incorporated in vehicles, infrastructure, and overall system design and operation, and accompanied by new technological aids to provide information and alerts to operators, dramatic safety benefits will result. Among other activities, this initiative will support the development of new simulator capabilities, such as those now being completed for motor vehicle operator research, that will add substantially to our understanding of operator behavior and decision making and assist in the evaluation of the human-machine interface.

Accident Avoidance Technologies: An important use of advanced information technology in transportation is the deployment of devices to improve operator awareness, warn operators of hazardous circumstances or imminent threats, or initiate responses to hazards. The ITS program, for example, includes a substantial component that seeks to exploit these possibilities through vehicle-wayside communications, whether by on-board devices or variable message signing. This proposed initiative will assess the potential of an additional category of opportunities for preventing accidents—vehicle-based systems, such as Positive Train Control. Other such systems include "smart ships," vessel tracking systems, air traffic alert and collision avoidance systems, synthetic vision (e.g., night vision aids), smart cruise control, collision warnings or automated braking, devices to detect vehicles in "blind spots," and sensors to detect that operator alertness has dropped to a hazardous level.

Training and Education: Even with a greatly improved understanding of human performance and a set of advanced collision-avoidance technologies that draw upon that knowledge, training and education will continue to be vital to ensure that vehicle operators are knowledgeable about safety systems and safe operational procedures for the vehicles they operate. This initiative will support the development of interactive

programs (e.g., CD-ROM video games, simulators) to train and evaluate vehicle operators under a wider range of operational scenarios than is currently possible.

II.3.a.ii. National Intelligent Transportation Infrastructure

Over the last decade, traffic in metropolitan areas has increased at a far faster rate than available road capacity. The daily vehicle-miles of travel per lane of urban highway has grown by nearly 30 percent, and this has led directly to greater congestion, energy use, air quality problems, and sprawl. During the past 15 years, both the number of trips per person and the miles per trip have increased at about 3 times the rate of population growth. Vehicle-miles traveled in urban areas have been growing at about 4 percent a year. In the face of this explosive growth in travel, the transportation system's capacity has not kept pace. DOT estimates that to just equal the growth in vehicle-miles traveled, the U.S. transportation system would need to build approximately 35 percent more highway capacity. Doing so for 50 of our most congested metropolitan areas—for which the total cost of congestion is \$43 billion a year— would cost about \$150 billion.

Initiative: National Intelligent Transportation Infrastructure.

Goal: Deploy an intelligent transportation infrastructure across the United States within the next decade.

Participants: DOT (FHWA, FTA, FRA, NHTSA); State DOTs; MPOs; emergency response and law enforcement agencies; private industry.

Benefits: Reduction in travel times in metropolitan areas; faster life-saving emergency response and fewer congestion-related traffic incidents; more efficient public services; reduced petroleum consumption; improved air quality; increased infrastructure capacity without costly new construction; enhanced information system security.

Congestion also has an impact on commercial motor vehicle travel, particularly when coupled with the administrative burden associated with regulatory compliance. Motor carriers are legally required to obtain numerous and information-intensive credentials and clearances for interstate operations. On the average, interstate carriers may deal with five or six public agencies within each of the states in which they operate. Regulatory compliance not only creates administrative inefficiencies and redundancies, but it increases labor costs. Total compliance costs for the industry are estimated to be as high as \$5 billion a year. The costs to the public sector are even greater, due to the volume of paperwork associated with motor carrier inspections, credentialing, and tax collection.

Rural transportation poses yet another set of challenges. The transportation needs of rural areas differ significantly from those of cities. Although less than 40 percent of annual vehicle-miles traveled are on rural roads, these roads account for 60 percent of all traffic fatalities because of higher speeds and relatively slow emergency response. Many rural residents are isolated, without a car or access to public transportation. Thirty-eight percent of rural residents live in areas without any transit services; another 28 percent live where the level of service is negligible. Moreover, visitors to rural tourist areas have limited access to directions and to other basic travel information.

Intelligent transportation systems, or ITS, offer promising solutions that respond to these pressing challenges in urban, commercial, and rural surface transportation. These systems are diverse and versatile, combining telecommunications, computer, sensing, and electronics technologies to provide real-time information to traffic managers and travelers on traffic, weather, navigation, and vehicle diagnostics—in much the same way that the air traffic control system does for air traffic—to achieve greater system efficiency, safety, and convenience.

In partnership with state and local agencies and industry, this partnership initiative will support the creation of a national intelligent transportation infrastructure—a transportation communications and information backbone—that will help to ensure that the various ITS strategies being deployed across the country are integrated, interoperable, intermodal, and secure. This national infrastructure comprises three broad systems:

Metropolitan ITS Infrastructure: This infrastructure will integrate advanced traffic management, traveler information, and public transportation systems to meet the needs of metropolitan areas.

Commercial Vehicle Information Systems and Networks: This will integrate data, technology, and communications systems to make safety regulation of commercial vehicles faster and more effective, and to make compliance transactions more efficient for both motor carriers and regulators.

Rural ITS Infrastructure: This infrastructure will upgrade communications and information technologies in rural communities and link rural areas to the metropolitan information infrastructure.

Through this initiative, Federal agencies will work with industry and state and local partners to deploy various elements of this overall infrastructure. The Federal role will include providing incentives for deployment, supporting public-private model deployments and technology demonstrations, developing innovative financing and acquisition processes, promoting the acceptance of national standards, providing training and technical assistance, and pursuing focused research and development. A major component of this effort will address the security concerns arising from opening new avenues of communication among transportation agencies, emergency services, other agencies, and the traveling public. Together with the increasing

dependence on information and communication technologies, this trend has heightened transportation systems' vulnerability to information security problems.

II.a.3.iii. Next-Generation Global Air Transportation

Initiative: Next-Generation Global Air Transportation.

Goal: Enhance aviation system safety, efficiency, and capacity by demonstrating next-generation concepts for air traffic management and validating the associated technologies, procedures, and operational benefits.

Participants: DOT (FAA, Coast Guard); NASA; DOD; airlines; manufacturers.

Benefits: Improved safety and efficiency of the air transportation system in the face of increasing demand in domestic and oceanic airspace; advancement of the state of the art in aviation communications, navigation, surveillance, weather, and decision-support systems; promotion of Government-industry cooperation in critical areas of aviation technology; and improved U.S. balance of trade for aviation technologies and products.

Recent Government-industry partnerships have developed a number of advanced technologies for air traffic management, as well as consensus on operational improvements required for enhancing the safety, flexibility, and efficiency of air traffic management operations. In particular, the "free flight" concept, developed in collaboration with U.S. airspace users, envisions a system wherein aircraft operators have wide latitude for selecting flight paths, speeds, and altitudes that best satisfy their operational requirements; the air traffic management system imposes restrictions only to ensure that aircraft are separated and that other essential safety requirements are met.

Most of the technologies that would foster free flight have been developed and tested on a small scale. The next step in the practical application of these technologies is integration, demonstration, and validation in the operational environment. This activity not only will set the stage for national deployment of the next-generation air traffic management system, but will affirm U.S. leadership in aviation by show-casing the new technologies and promoting global markets for U.S. aviation products.

This initiative will implement and validate advanced air traffic management technologies and procedures under real-world conditions. The activity is essential to FAA and industry efforts to evaluate the consequences of changes in the operational concepts and procedures required to exploit the new technologies. The potential of the new technologies has been successfully demonstrated—on a limited scale for helicopters—at the 1996 summer Olympics in Atlanta.

There, the FAA, in partnership with the Olympic Committee, industry, helicopter operators, and NASA, demonstrated the use of satellite-based navigation and surveillance techniques in managing the large number of passenger, cargo, and security helicopters supporting the games.

The proposed effort would implement and demonstrate the new system in two regions, one each in Alaska and Hawaii. Hawaiian airspace is an ideal location because it is geographically isolated and serviced by a relatively small number of aircraft, making technology upgrades more affordable and manageable. Further, because Hawaii is a popular international destination, it offers a unique opportunity to showcase U.S. technologies for the rapidly growing aviation markets in Asia and elsewhere. Alaska also has the advantage of relative geographic isolation. In addition, it provides challenging weather conditions and terrain that the new system addresses by providing relevant safety information in the cockpit. The demonstration in Alaska therefore will validate the ability of the new technologies to significantly increase the safety of flight operations.

This initiative will exploit and expand existing partnerships among industry, airspace users, the FAA, NASA, and DOD. These collaborations created the concept of free flight, and have been productive in developing and testing the new air traffic management technologies that provide a basis for the next-generation system. Safe Flight 2000 is the essential next step in air traffic management system development.

II.3.a.iv. Enhanced Transportation Weather Services

For the transportation system, the safety, mobility, and economic impacts of adverse weather conditions are considerable. According to a report of the Office of Science and Technology

Initiative: Enhanced Transportation Weather Services.

Goal: Improve transportation safety and efficiency by demonstrating the data-integration capabilities necessary to provide short-term, very small scale weather forecasts.

Participants: DOT (FAA, FHWA, Coast Guard, FRA); NWS; private vendors; state and local agencies.

Benefits: In aviation, improved capabilities for flight planning and severe weather avoidance, greater system throughput, reduced fuel consumption, and lower deicing costs for airports; for ocean shippers, financial savings due to forecasts that allow planning for the most efficient routes; and in surface transportation, reduced highway accidents and related injuries, lower costs for trucking firms, and lower snow- and ice-control costs for state and local highway departments.

Policy (OSTP), each year weather causes or contributes to 6,000 fatalities on U.S. highways and 800 aviation-accident-related deaths. The OSTP estimates that more than half of all flight delays are attributable to weather, and that uncertainties in predicting flight-level winds add a quarter billion dollars annually to the nation's aviation fuel bill. Moreover, the FHWA states that between 25 and 35 percent of all intercity road accidents occur during adverse weather, with the risk of accidents increasing during bad weather by a factor of from 2 to 5.

Advances in weather technologies and meteorology during the past decade offer the promise of mitigating many of the impacts of severe weather on transportation. Among these are new observation systems, such as Doppler radars and Automated Surface Observing Systems; advances in computing speed and capacity; and greater fundamental knowledge of weather systems. In fact, weather observation and information-processing capabilities have expanded so greatly that it is now feasible to combine weather data from many sources into massive databases and manipulate the data with numerical models to produce reliable short-term weather forecasts for individual roads, traffic arteries, bridges, airport runways, air corridors, ports, and waterways. However, the full potential of such small-scale forecasting will not be realized without further improvements in weather data integration and dissemination. Of immediate utility, when available, will be the results of the ongoing research to develop message sets and protocols for the road-weather information system under the National Transportation Communications for ITS Protocol (NTCIP) project.

The benefits of such improvements are already being demonstrated. For example, at Chicago's O'Hare International Airport, the National Center for Atmospheric Research, as part of an FAA initiative, has combined radar and sensor data to provide snowfall predictions for up to 30 minutes for 1-square-kilometer areas of the airport complex. The data integration is accomplished using a high-performance computer workstation. Snowfall forecasts are displayed in graphical form on monitors in the airport and airlines' operations centers. This same capability will be demonstrated at New York's LaGuardia Airport in collaboration with the Port Authority of New York and New Jersey.

Building upon this work and the forecasting capabilities already developed by the NWS, this partnership initiative will provide the planning and underlying infrastructure required to integrate all radar, sensor, and satellite data with local geographical information within a selected state and provide 30-minute, and eventually up to 120-minute, localized statewide weather forecasts.

II.3.a.v. Enhanced Goods and Freight Movement at Domestic and International Gateways

The Nation's economic success relies on access to worldwide markets for its goods and services. However, as other countries vie for global and U.S. markets, America's competitive position continues to be challenged. Critical to the Nation's future competitiveness is the development of an enhanced integrated transportation system for the movement of international

and domestic freight, based on advanced infrastructure technologies and more efficient communication and information systems.

Initiative: Enhanced Goods and Freight Movement at Domestic and International Gateways.

Goal: Enhance U.S. economic growth by expanding the overall share of global and domestic trade markets through advances in transportation technology and systems.

Participants: DOT (MARAD, FRA, FAA, FHWA, NHTSA); DOC; and other organizations representing the public, private, and defense sectors.

Benefits: A more productive, competitive national economy and a more flexible, efficient, and seamless U.S. freight transportation system.

It is increasingly accepted that efficiency is improved and costs reduced when international and domestic freight moves along integrated "pipeline" systems from origin to destination, linking various modes as required. Reliance on just-in-time production and inventory management practices has increased the demand for better freight transportation, yet inefficiencies at any point in the pipeline can disrupt the total system—resulting in reduced profits for transportation providers and higher costs for freight shippers and consumers. The goal of freight transportation R&D must therefore be to develop seamless intermodal networks for the entire trip—from origin to destination.

This partnership initiative will develop segments of such a seamless, intermodal freight transportation system. On the water side, this initiative will focus on advanced terminal design and operating systems that complement changing ship designs and operations. On the land side, this effort will incorporate advances in high-speed freight rail networks, truck/container transport and handling systems, truck/airport interface systems, and rail/truck/water interface systems. This will include consideration of revolutionary concepts such as unmanned underground tube freight capsules. Such concepts must be considered from the standpoint of capital and operational cost, as well as compatibility with current freight transport systems--staff at the Volpe National Transportation Systems Center have, for example, recently completed an initial study of such issues for the tube freight concept. Each of the above segments also will require application of communication and information systems technology and infrastructure.

As a public-private partnership, this initiative will dovetail and supplement existing programs that address critical elements of an enhanced, integrated freight transportation system. One such program is the President's shipbuilding revitalization initiative. This program's R&D element, called MARITECH, focuses on advanced commercial ship designs and modernization

of shipyard facilities, processes, and procedures. Another element of the President's revitalization plan is the Title XI loan guarantee program, which to date has financed more than \$143 million in U.S. shipyard modernization projects.

II.3.a.vi. Accessibility for Aging and Transportation-Disadvantaged Populations

Initiative: Accessibility for Aging and Transportation- Disadvantaged Populations.

Goal: Create seamless regional alternative transportation systems serving the needs of the elderly and transportation-disadvantaged while optimizing the existing human and capital investment in paratransit.

Participants: DOT (FTA, FRA, FAA, FHWA, NHTSA); HHS; private vendors; and state, regional, and local government agencies.

Benefits: Reduced health care costs for the elderly; reduced welfare expenditures and improved job placement and retention for welfare recipients; and reduced public outlays for new equipment through improved management of existing infrastructure and assets.

Although the United States possesses one of the safest and most extensive passenger transportation systems in the world, the system is unable to provide optimal mobility for selected and growing portions of the population. These segments include the elderly, the physically challenged, and the poor:

- Today, 12 percent of the population is 65 or older. Estimates suggest that by the year 2020, up to 20 percent of the population will be over 65, and the fastest growing cohort will be those least likely to have easy access to automobile transportation—those 85 and older.
- Those young or old with physical disabilities have considerable mobility needs. Transportation to medical facilities, schools, training centers, and workplaces are critical to their health and well-being.
- The transportation needs of the poor, particularly inner-city and rural populations, have been an important priority in national transportation and human service policies. However, recent welfare reform legislation requiring states to implement welfare-to-work programs places renewed emphasis on the importance of mobility for those attempting to access and retain employment.

Even for those with access to automobiles, mobility is not assured. In many urban areas, road congestion extracts a high cost in delay, irritation, safety, energy use, and adverse environmental impacts. Yet, demand for transportation services continues to increase. Most areas in the U.S. where such congestion is a problem can no longer respond by simply building more physical infrastructure. The answer necessarily lies in innovations that permit more effective and efficient use of the existing system, with greater intermodalism and seamlessness among the varied system elements.

Government investment in paratransit has provided the vast majority of the transportation options available to these populations. Paratransit is typically defined as flexible-route, low- or medium-capacity vehicles serving a predetermined group of people, such as the elderly, for a fee. The need for these services is growing. Demand-responsive paratransit nationwide has doubled the number miles traveled over the last 10 years to nearly 600 million miles per year.

Although paratransit fills an important transportation gap for many parts of the population, its financial viability has been underwritten with substantial government funding—Federal, state, local, and private—rather than from its own revenues. High operating costs and poor management strategies that do not optimize the use of drivers and vehicles have made such services costly and less than fully responsive to their riders' mobility needs.

This partnership initiative will improve the regional mobility of the elderly and transportation-disadvantaged through better management of paratransit operations and assets. This will be achieved by developing, deploying, and testing a program that will utilize selected information system technologies and applications, including automatic vehicle location, state-of-the-art vehicle communications, geographical information systems, computer-aided dispatch, and electronic fare collection. These technologies will be integrated into a centralized regional control system to manage otherwise independent paratransit operators. Centralized dispatch, monitoring, and fare collection for regional paratransit services provided by transit properties, Councils on Aging, and human service providers within a single region will be conducted from a regional mobility management center.

Although a number of "smart" technologies are currently being used or individually demonstrated throughout the country, no single regional testbed exists that attempts to manage all paratransit services within a region. The power and reduced cost of commercial off-the-shelf information, communication, and navigation systems makes possible the deployment of a regional access and mobility program.

II.3.a.vii. Local Environmental Assessment Systems

Assessment of environmental impacts, and of the cost-effectiveness of countermeasures, is in most cases a very difficult process. For example, urban air pollution depends in part on vehicle emission characteristics, patterns of travel, weather and climate conditions, and very

complex atmospheric chemistry and physics. Moreover, it is often not possible to predict accurately the travel behavior changes that may be associated with a particular air-quality change, whether involving road construction, traffic control, or demand management.

Initiative: Local Environmental Assessment Systems.

Goal: Further develop data, validated models, and a comprehensive knowledge base to support analysis of transportation-related environmental impacts and alternative strategies, including use of "virtual travel," by all levels of government and the private sector.

Participants: DOT, EPA , other responsible Federal agencies, state and local environmental authorities, National Laboratories, the private sector, academia.

Benefits: Improved ability of government agencies to respond strategically to environmental objectives and to characterize the transportation implications of those objectives.

As a result, many uncertainties surround the environmental aspects of major transportation investment and regulatory decisions. This can be an especially serious problem for local government planning bodies, which often lack the sophisticated tools and technical staff needed to deal with such complex issues. Significant new opportunities, including new operational practices made possible by dramatic improvements in information technology, are being made available to MPOs and local agencies. However, in order to understand the possibilities and make effective choices, these organizations require models capable of predicting the range of impacts of such practices.

Problems also can arise in the degree to which environmental regulatory agencies appreciate the transportation impacts of their decisions. Since the consequences for transportation system performance, public health, and overall quality of life can be severe, it is critical that the Federal Government conduct a wide range of research activities focused on clarifying all aspects of major transportation-related environmental issues. The recently proposed tightening of U.S. standards for ambient concentrations of ozone and fine particulate matter, for example, would likely expand the geographic scope of non-attainment and create the need for additional measures to reduce transportation sector emissions. This topic also has a large international component. International agreements to limit emissions of carbon dioxide and other gases could have profound consequences for domestic transportation.

Another need that this initiative will address is for an increased understanding of the relationship between transportation and land use decisions. This effort will support the development of analytical tools that MPOs and other transportation decisionmakers can use to

assess the implications of transportation projects for overall sustainability, including land use, economic development, and accessibility.

The development of such tools is the primary objective of FHWA's Highway Planning research program, discussed below in Section III, Chapter 6. Priorities of this program include the development of sketch planning tools for assessing ITS deployment options; the development of innovative data collection methods; and implementation of the Travel Model Improvement Program (TMIP) and TRansportation ANalysis SIMulation System (TRANSIMS) program.

This partnership initiative will develop data and analytical models to provide a comprehensive environmental knowledge base to support decisions, policy formulation, and transportation investments in all modes. It will expand and build upon the work conducted under the TMIP, an interagency effort aimed at developing a new generation of travel demand models. The TMIP includes both research to enhance current modeling practice and a longer term initiative to develop a new approach using the latest advances in computing technology (known as TRANSIMS). This new approach uses microsimulation to depict travel patterns and couple them with a modal emissions model, allowing Metropolitan Planning Organizations (MPOs) and other agencies to fully analyze the implications of various transportation investments on both travel characteristics and emissions.

Another need that this initiative will address is for an increased understanding of the relationship between transportation systems and land use decisions. This effort will support the development of analytical tools that MPOs and other transportation decision makers can use to assess the implications of transportation projects for overall sustainability, including land use, economic development, and accessibility.

II.3.b. Next-Generation Vehicles

II.3.b.i. Next-Generation Motor Vehicles and Ships

There are four prominent national concerns which, together, will require significant advances in transportation vehicle technology. First, the U.S. relies on petroleum to provide more than 95 percent of the energy required for transportation, and it has been estimated by some researchers that even a brief supply curtailment (i.e., 2 years) could drain \$500 billion from the economy. Second, although the U.S. has advocated the adoption of binding international commitments to stabilize the atmospheric concentration of greenhouse gases, continued growth of U.S. transportation sector emissions is projected under current policies. Third, while recent improvements have been realized in urban air quality, additional measures for mobile sources would be required to meet tighter proposed standards for ozone and fine particles. Finally, U.S.-based component and vehicle manufacturers face growing international competition, and must continue to make technological gains to compete effectively in the world marketplace.

Initiative: Next-Generation Motor Vehicles and Ships.

Goal: Develop internationally competitive, domestically produced motor vehicles and ships that achieve unprecedented gains in fuel efficiency, environmental performance, and operational performance.

Participants: DOT (FTA, FRA, MARAD, NHTSA, Coast Guard); DOC; EPA; DARPA; DOE; state and local authorities; National Laboratories; universities; component suppliers; fuel producers; engine and vehicle manufacturers; fuel cell producers; and new energy conversion technology manufacturers.

Benefits: Reduced economic vulnerability to petroleum supply curtailments; reduced emissions of greenhouse gases, ozone precursors, and fine particulate matter; improved transit service; improved intercity transportation service in high-density markets with airport capacity and landside access constraints; improved global competitiveness of U.S. truck, bus, and locomotive manufacturers; establishment of domestic manufacturers as leaders in production of new energy-conversion systems; revitalization of U.S. maritime carriers and shipyards; and provision of surge capacity essential to national security.

This partnership initiative responds to these concerns through R&D leading to the development of transportation vehicles that are more efficient and far less polluting. Specifically, this effort will seek to develop the next generation of:

Highway Vehicles: This initiative will continue the PNGV and Advanced Technology Transit Bus (ATTB) activities and will supplement them by also focusing on dramatic improvements in medium- and heavy-duty-vehicle fuel efficiency. This complements, and must be coordinated with ongoing research supporting the establishment of effective safety regulations applicable to such vehicles--a core DOT responsibility. In 1993, the Clinton Administration joined in a historic partnership, the PNGV, with the Big 3 automakers to establish global technical leadership in the development and production of affordable, fuel-efficient, low-emission automobiles that meet today's safety and performance standards. However, while automobiles account for 40 percent of the nation's transportation energy demand, heavy vehicles--buses and trucks--still consume 25 percent of the total energy used for transportation. These vehicles, which tend to use diesel fuel, are also responsible for major shares of transportation sector emissions of nitrogen oxides and fine particles. In recent years, the FTA has worked collaboratively with the transit industry to develop the first prototype ATTB. This bus uses lightweight composite materials and an electric drivetrain to achieve a

four-to-five-ton reduction in curb weight, low emissions, and reduced fuel consumption.

Locomotives: DOT's Strategic Plan calls for the development of high-speed rail as a viable transportation option in select corridors. The primary market for this service is generally perceived to be trips of from 100 to several hundred miles in length. Although many routes may well prove viable for higher speed trains—in the range of 100 to 125 MPH or faster—applications in the U.S. require a non-electric high-acceleration locomotive. Although most high-speed technology uses electric propulsion, virtually the only portion of the U.S. rail system currently electrified is the Northeast Corridor—and the cost of electrification is daunting. This partnership initiative will support the development, test, and demonstration of non-electric, high-speed rail technology to establish a technological context in which public agencies and private industry can proceed to implement new rail services.

Ships: International freight transport is critical to this country's participation in the global economy. Total oceanborne foreign trade in 1994 had a value of \$566 billion, up 13 percent from the previous year. Moreover, commercial sealift is the primary means of deploying military assets abroad. Sufficient surge capacity, including readiness for conversion of ports and a portion of the commercial fleet from civil to defense functions, is therefore essential to national security. It is thus important to the nation that there be a U.S. merchant fleet capable of competing internationally on a cost and service basis. By supporting focused R&D designed to stimulate and foster innovation in ship design and shipbuilding, this initiative will provide Federal participation and leadership necessary to ensure national defense readiness and to restore the health of the U.S. maritime industry. This includes not only ship structure but also ship propulsion. For example, recent Navy demonstrations of fuel cells could form the basis for a partnership with the Coast Guard to develop this technology for wider use in ships and, potentially, for land transportation vehicles such as locomotives, buses, trucks, and automobiles.

II.3.b.ii. Aviation Safety Research Alliance

Great strides have been made over the past 40 years to make flying the safest of all of the major modes of transportation. Aviation accidents have leveled off at extremely low rates. However, although the accident rate is very low, it has stayed relatively constant for the past decade or so. Moreover, the significant projected growth in air traffic in response to global demand has the potential to cause the total number of accidents to rise dramatically throughout the entire aviation system over the next 20 years.

Initiative: Aviation Safety Research Alliance.

Goal: Provide the technology to reduce fatal aviation accident rate by a factor of five in 10 years and a factor of 10 in 20 years.

Participants: NASA, DOT (FAA), DOD, airlines, manufacturers, universities.

Benefits: Reduced aviation accidents and accident-related fatalities and improved capacity to meet safely the growing world demand for air transportation.

This partnership initiative addresses these long-range issues proactively through an alliance between government and industry to develop and deploy innovative technologies and products that (1) reduce human-error-caused accidents in aviation by a factor of ten over 20 years; (2) eliminate hazardous weather as a cause of aviation accidents; and (3) reduce by half accidents due to malfunctions of safety-critical aviation systems. The FAA will continue its research that focuses on addressing immediate operational safety issues and results most frequently in safety-critical rulemaking. In contrast, the innovations that will be the outcomes of this research alliance will be developed for incorporation by industry as new products in future aircraft or as additions or alterations to existing aircraft or procedures. Specific areas for this long-range technology development include:

Aircraft Systems: Prevent malfunctions of aircraft equipment and systems through innovations in aircraft design, manufacture, monitoring, inspection, and repair prior to malfunction.

Human Factors: Eliminate human-caused mishaps through human-centered aircraft and system design, alternative procedures and processes, and improved education and training.

Environment: Ensure separation between aircraft and hazardous weather, terrain and obstructions, other aircraft and their wakes, and hostile action (military/security).

II.3.c. Transportation Physical Infrastructure

II.3.c.i. Total Terminal Security

The years since the outbreak of Middle Eastern terrorism in the 1960s have seen an intermittent cycle of both increases and declines in major incidents of public terrorism or violence throughout the world. The occurrences of such incidents is often, of course, heavily

dependent on local or regional political circumstances. However, recent events in both the U.S. and other parts of the world—including the bombings of the World Trade Center, the Federal Building in Oklahoma City, and Olympic Park, and several attacks against transit operations in such widely scattered cities as Tokyo, Paris, and Baku—have focused considerable attention on the vulnerability of transportation facilities and the potential for another upsweep in the number and severity of terrorist attacks.

Initiative: Total Terminal Security.

Goal: Develop a standardized approach to assessing the security threat at transportation facilities and implement a standard security package specifically tailored to that level of threat.

Participants: DOT, the intelligence community, domestic law enforcement agencies, state and local transportation and law enforcement agencies, airport and port authorities, and public and private transportation service providers.

Benefits: Greater security for transportation users and operators through the development of a standard approach for assessing vulnerabilities and risks at transportation facilities and the collection of valuable information regarding cost-effective allocation of security resources and implementation of security measures.

Because of their visibility, transportation facilities and operations have frequently been the target of such incidents. It is only prudent that transportation officials carefully study the potential threat to their own facilities and operations and develop cost-effective measures that can be taken to minimize the number and severity of incidents. Doing so, however, will require the participation and assent of all agencies and organizations active in this area, including Federal, state, and local agencies with transportation, law enforcement, and threat-analysis responsibilities; airport and port authorities; and private transportation service providers.

This initiative will modify an approach taken by the State Department for application to major transportation terminals, facilities, and operations. This concept, called "Total Terminal Security," will enable the transportation community to apply a standard, acceptable methodology to the allocation of security resources and implementation of security measures at each location. In practice, this concept will cover the range of major security elements, including physical security and public access controls, personnel security, perimeter security, technical security, and, where relevant, communications and information systems security.

One example of a transportation facility to be included in this approach is domestic airports. Under this initiative, new systems for detecting weapons and explosives will be incorporated

with other developments in physical security and passenger profiling into a "package" implemented at three to five airports to assess its effectiveness as a total integrated system. The selected airports will become operational laboratories for validating the integration of airport and airline security, new security technology, and the participation of various organizations such as local government agencies, the Federal Bureau of Investigation, and others. Using three to five different airports will help to identify problems that may arise when the total security concept is applied to specific airports. The airports' security systems will be evaluated in terms of passenger and cargo throughput, delay time due to the inspection process, and operating costs. If the total security concept works as well as expected, the test airports will serve as models for the rest of the Nation's airports and for the international community.

This airport security activity is already well under way. The Federal Aviation Administration has accomplished simulations of total security packages and, based on these simulations, has developed projected deployment plans. This initiative would expand current work to the three to five operational tests at airports and develop similar integrated security packages for other transportation facilities, including shipping, rail, and transit terminals.

II.3.c.ii. Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure

The Nation's transportation infrastructure is aging—its elements either nearing or exceeding their design life. This aging infrastructure must be incrementally restored, renewed, and strengthened. Many elements also require capacity expansion if our growing needs for transportation are to be met. Yet, there is a pressing need to "do more with less" in maintaining the physical infrastructure for surface, air, marine, and multimodal nodes in transportation. The DOT Report to Congress, *1995 Status of the Nation's Surface Transportation System: Conditions and Performance*, estimated that an annual investment of approximately \$57 billion would be required from all sources just to maintain current conditions, with \$80 billion required to provide a higher level of service by correcting existing deficiencies, including expanding capacity. Moreover, several major airports, which were not addressed in this report, suffer from severe and growing landside congestion delays and capacity shortfalls, while more than \$4 billion is spent each year to maintain, repave, and expand existing runways.

Reducing the backlog of needed infrastructure rehabilitation and renewal, and meeting the critical need for improved infrastructure performance and capacity, poses major challenges in terms of life-cycle cost, safety, reliability, and environmental impacts. The growing maintenance funding gap can be bridged only by restructuring the technology base for physical infrastructure renewal.

Initiative: Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure.

Goal: Stimulate and facilitate the effective use of both innovative and conventional construction designs, structures, materials, and methods in the rehabilitation, renewal, and replacement of the physical transportation infrastructure.

Participants: DOT, DOD, DOC (NIST), NSF, CERF, transportation construction firms, manufacturers, state and local transportation agencies.

Benefits: Improved safety and economic productivity of the physical infrastructure through reduced likelihood of catastrophic failure, lower life-cycle investment for system renewal and expansion, and fewer service interruptions.

This initiative proposes strategic joint R&D investments in key technologies to ensure the safe operability of the aging infrastructure and timely detection of deteriorating conditions. These infrastructure technologies fall within three areas:

Renewal Engineering: This technology area covers the use of improved materials, designs, and methods for infrastructure. Specific technologies include new construction methods such as automation and robotics, trenchless and other advanced tunneling, and efficient cut-and-cover; advanced structural materials, including durable composites and metal-composite hybrids; and advanced paints and spray coatings.

Advanced Infrastructure Inspection, Monitoring, and Maintenance: Included in this technology area are nondestructive test and evaluation technologies and "smart" sensors and materials, such as embedded fiber optics for visual inspection or strain interferometry, shape-memory alloys, and ultrasonic or magnetic corrosion detection.

Environmental Engineering and Technologies: This area promotes the use of recyclable materials and environmentally benign technologies to prevent or mitigate the adverse environmental impacts of infrastructure construction and operation. These materials and technologies include green barriers to shield noise and improve air quality; paint and spray recovery systems; non-toxic and recyclable bridge and road coatings, asphalt mixes, and additives; geotextiles for slope stabilization and surface-life extension; and use of recycled tires, plastics, and pavements in infrastructure applications.

II.3.c.iii. Environmental Sustainability of Transportation Systems

Transportation systems have been recognized as having major impacts on environmental sustainability. The transportation sector accounts for about one-third of domestic contributions to greenhouse gas emissions and is the fastest growing contributor both domestically and internationally. Transportation sector impacts upon the health of soils and aquatic resources, as well as habitat disruption, are often irreversible, with unknown long-term ecological consequences. The land use decisions made by governments and individuals are long-lasting and to a large extent determined by the availability of inexpensive transportation choices.

Initiative: Environmental Sustainability of Transportation Systems.

Goal: Investigate the technological and behavioral implications of alternative transportation infrastructures and development patterns to determine those that minimize impacts on long-term environmental sustainability.

Participants: DOT, EPA, DOE, HHS, HUD, the private sector, academia, nongovernmental organizations, and state and local government agencies.

Benefits: Improved ability to understand the linkages between transportation and the environment, and how more sustainable transportation systems benefit society.

These issues are not easy to address and create substantial challenges for the research community. Finding solutions that enhance the sustainability of transportation systems requires applications of technology as well as an understanding of the behavioral and social sciences. Research is needed to determine the technology necessary to design transportation systems and development patterns that provide access to economic, social, and recreational opportunities such that permanent (i.e., unsustainable) environmental degradation is minimized or avoided.

Examples of potential research areas under this initiative are:

Behavioral research associated with development patterns: Technical solutions for devising development patterns that produce environmentally cleaner and safer environments are a means of reducing vehicle-miles of travel (VMT) both to reduce environmental problems and to increase the safety of communities. Research is needed to determine how aspects of human behavior such as mode choice, travel demand, and driver behavior are affected by development scale, the scale of hierarchical transportation infrastructures, and their interaction.

Impacts of transportation infrastructure on climate change: Providing additional transportation capacity "induces" or attracts new trips, as acknowledged by the recent Transportation Research Board special report, *Expanding Metropolitan Highways*. Both short-term and long-term effects tend to reduce any initial travel-time benefits associated with increases in capacity. Additional research is needed to clearly document both short- and long-term effects, especially the implications for greenhouse gas emissions. Research is also needed to determine whether transportation infrastructure can be designed in concert with development patterns such that accessibility is maximized.

Information technologies and sustainable development: Many information technologies offer solutions that can increase the sustainability of transport systems, especially when combined with development patterns that are more sustainable. For example, telecommuting offers the promise of accessibility without mobility and may be particularly beneficial for promoting development of sustainable communities. Research into the behavioral implications of telecommuting and other information technologies, such as adaptive transit dispatching, can identify the implications for sustainability, such as whether they result in major changes in travel demand and patterns.

Infrastructure needs associated with revitalizing urban areas and cleaning up brownfield sites: Brownfields typically are abandoned and mildly contaminated sites that require minimal clean-up efforts. Redevelopment of these and other urban sites can promote sustainability by avoiding development of ex-urban greenfields. Urban infill development can reduce the need for building ex-urban transportation infrastructure and reduce VMT growth. Urban brownfield sites also often have unmet infrastructure requirements that need to be addressed. Technological solutions, such as information technologies, may be able to identify and facilitate clean-up requirements while providing a transportation solution for abandoned urban areas.

Sustainable freight movement: Efforts to reduce traffic congestion and emissions in urban areas have often taken the form of restrictions on freight movement in favor of facilitating (primarily single-occupant-vehicle) personal travel. Additional research is needed on the long-term regional economic and environmental impacts of current freight policies and opportunities provided by new information technologies, intermodal facilities, and market-based measures for improving the energy efficiency of freight movement in urbanized areas.

Overall, this partnership initiative will address the sustainability of building and operating the interrelated and complex systems of transportation and development that drive, and are driven by, economic activities. The focus will be on behavioral sciences and interactions with technology in determining how people react to different systems to achieve sustainability.

CHAPTER 4

DEVELOPMENT OF THE ENABLING TECHNOLOGY BASE

Innovations in transportation generally result from application of a wide range of scientific and engineering disciplines not specific to transportation. Continual research in these areas is necessary to provide a solid foundation for the steady advances in transportation technology required to meet the demands of the 21st century. Yet, the long-term nature and often diffuse benefits of such research means that market forces may be insufficient to motivate private investment. Moreover, while many Federal agencies conduct research in these areas, that R&D is typically focused on the agencies' specific concerns—not on broader national needs. As stated in the General Accounting Office report on *Surface Transportation Research Funding, Federal Role, and Emerging Issues*, as well as by numerous transportation officials, "the current mix of research projects gives too little emphasis to basic, long-term, high-risk surface transportation research." Examples of such research that is conducted by the Department of Transportation include the Crash Avoidance Research and Automated Vehicle Control and Information Systems programs.

The third tier of the NSTC *Transportation Science and Technology Strategy* identifies six long-term research areas. These are consistent with the principles of the President's Committee of Advisors on Science and Technology, meet the criteria listed in the box to the right, and support one or more transportation system elements. These enabling research areas are (1) human performance and behavior; (2) advanced materials; (3) computer, information, and communication systems; (4) energy and environment; (5) sensing and measurement; and (6) tools for transportation modeling, design, and construction.

Criteria for Enabling Research

- Supports long-term national transportation goals.
- Benefits too widely spread for any one company to recover its investment at a profit.
- Cost or risk is too great for any individual company to bear alone.
- Benefits too far in the future to pass threshold of private investment criteria.

In the third edition of this *Surface Transportation Research and Development Plan*, DOT shaped a long-term research agenda that would facilitate realization of the Department's vision and strategic goals by focusing on transportation challenges for the 21st century and identifying priorities for allocation of scarce R&D resources. The report identified sixteen strategic long-term R&D thrusts (Section II, Chapter 4) that, to a large degree, were based upon and incorporated existing R&D activities. The descriptive framework used did not imply

any particular new approach or process for implementation. Rather, the report proposed that each thrust area be pursued in a manner based on, and in harmony with, existing efforts.

The NSTC group of six enabling research areas represents a consolidation of the full set of programmatic long-term surface transportation R&D thrusts identified in the third edition of the *Surface Transportation Research and Development Plan*. It also reflects significant prioritization according to the above-mentioned criteria for Federal support. Table II-4-1 illustrates the relationships between the current enabling research areas and the previous long-term R&D thrusts.

Long-Term Research Thrust	Enabling Research Area					
	Human Performance and Behavior	Advanced Materials	Computer, Information, and Communications Systems	Energy and Environment	Sensing and Measurement	Tools for Transportation Modeling, design, and construction.
Transportation System Assessment and Knowledge Base	X		X		X	X
Intermodal Freight Transportation			X			X
Revitalization of the U.S. International Freight Transport Industry			X	X		
Improved Materials, Designs, and Methods for Renewal Engineering		X			X	
Advanced Technologies for Inspection, Monitoring, and Maintenance of Vehicles and Infrastructure			X		X	
Application of Information Technologies to Transportation Systems Operations	X		X		X	
Advanced Technology for Intermodal Public Transit Systems		X	X	X		X

Technical Foundation for High Speed Ground Transport Systems	X		X	X	X	
Accident Avoidance	X		X		X	
Accident Survivability		X	X			
Safety Data and Analysis	X		X			X
Security in Surface Transportation	X		X		X	
Environmental Impact Data, Models, and Knowledge Base			X		X	X
Environmental Engineering and Technologies		X		X		
Accessibility for Persons with Personal Mobility Limitations	X		X			
Intermodal Transit System Innovation	X		X			

Table II-4-1. Relationship between Long-Term R&D Thrusts and Enabling Research Areas

II.4.a. Human Performance and Behavior

For transportation systems to achieve high goals for performance and cost, their design, realization, and use must be based on (1) extensive knowledge of user needs; (2) limitations associated with human performance and behavioral characteristics; and (3) understanding of the many factors affecting the interaction between humans and automated systems.

Human error or inadequacy in vehicle or system operation, maintenance, or inspection is a leading factor contributing to safety and security problems. This arises in part because basic system design, operational procedures, or training programs do not take fully into account the characteristics likely among the people responsible for operating the system. Research in the behavioral sciences provides a critical foundation for building the needed transportation knowledge base to avoid such flaws.

Better understanding of human behavior is particularly needed in system control and operations, including the effects of fatigue, work-sleep cycles, working environment, boredom, and drug and alcohol use; response to emergency situations; testing of readiness to perform duties; and interactions among co-workers. In addition to affecting safety, problems associated with these topics cause operational inefficiencies that lower overall productivity. A broadly based research program will yield behavioral science results and methodologies for all modes of transportation, enabling more efficient use of scarce resources.

II.4.b. Advanced Materials

Technical advances in the defense and consumer sectors have produced a rich inventory of materials and associated structural concepts, tools, and techniques for their use. Enabling research in this area supports applications to transportation infrastructure, including the demonstration of effectiveness and long-term viability and, often, the reduction of costs to a competitive level. Examples include high-performance concrete, new steel alloys, innovative composite materials and adhesives, imaginative structural concepts, computer-aided design techniques, automated construction and maintenance tools, and new approaches to corrosion protection and control.

Similarly, transportation safety and energy use are greatly influenced by the materials from which aircraft, ships, and surface vehicles are manufactured. For example, the PNGV seeking a three-fold increase in automobile fuel economy is exploring the use of high-performance steel, aluminum, magnesium, and glass- and carbon-fiber composites for body structures. Each potential application of an innovative material poses new challenges in terms of material cost, manufacturing processes, joining and adhesives, characterization of failure mechanisms, environmental concerns, and costs compatible with transportation uses.

II.4.c. Computer, Information, and Communication Systems

Worldwide, transportation is being transformed by the growing overlay of an information infrastructure on the existing physical infrastructure yielding a system in which information technologies and ready access to many types of information are integrated into virtually all elements and functions to enable greater efficiency, safety, and improved performance. Effective and rapid exploitation of these innovations will require a substantial and ongoing enabling research and development effort associated with system concepts, characterization of alternative configurational and technical choices, and development and harmonization of a wide range of standards.

For example, increased use of wireless communication throughout the society and economy will require a solid technical and economic knowledge base to support policy decisions regarding allocation and efficient use of electromagnetic spectrum and sophisticated mobile data communications technologies. Similarly, many important transportation applications use the highly-accurate Global Positioning System for position-finding and navigation. Many technical as well as financial and institutional issues must be resolved to assure that this system evolves and is managed in a manner that fully reflects the growing needs of civil transportation users. The basic standards for electronic data interchange, database synthesis, and system interoperability are being addressed by appropriate trade and technical organizations, but the Federal Government has a critical role to play in facilitating that process.

The growing complexity of intelligent systems and ever greater dependence on them for human safety and functioning of the society will require a high level of reliability and robustness.

Similarly, a transportation system permeated with information technologies has significant new vulnerabilities to terrorist and other malicious attacks. Coordinated Federal research is needed in software modeling and verification techniques and High-Confidence Systems—information systems that provide users with high levels of security, reliability, and restorability. High-Confidence Systems are resistant to failure and malicious penetration or damage, and respond to interference via adaptation or recovery.

Information technology also plays a critical role in technology integration which is essential to rectify current inadequacies in system assessment, policy research, and intermodal research, as well as the widely supported needs in basic, long-term, high-risk research.

II.4.d. Energy and Environment

Economic and environmental characteristics of transportation vehicles are determined to a large degree by the means by which stored energy is provided and converted into kinetic energy. Each candidate technology is typically of potential relevance to at least several modes of transportation, and many have the ability to improve both energy efficiency and emission characteristics. Research in this area includes electric propulsion and battery concepts, advanced internal combustion engines, hybrid designs, and incorporation of innovations such as fuel cells and flywheel energy storage. As discussed above in *II.3.b.1.*, one promising example for which a near-term partnership may be warranted is the Diesel-fed fuel cell demonstrated recently by the Navy—another such example is the FTA fuel cell transit bus program. A variety of alternative fuels are possible, each with strengths and weaknesses in terms of economics, practicality, and indirect impacts. Market forces tend primarily to motivate propulsion system research for near-term application, necessitating cost-shared Federal R&D—such as the PNGV—to explore the longer term and higher risk technologies.

II.4.e. Sensing and Measurement

The wide range of information technologies now being incorporated into transportation systems has steadily increased the value of real-time monitoring and inspection of transportation vehicles and infrastructure. "Smart structures"—roads, bridges, runways, tunnels, and others with a network of embedded sensors—can yield lower cost with increased safety margins by continually providing detailed condition status and information, under normal as well as abnormal circumstances. "Smart vehicles" similarly depend to a large degree on sensing their environment and operating circumstances, processing that information, and communicating with other "smart" structures and vehicles to coordinate responses. The benefits of coupling sensing, computing, and communicating in this manner include safety, vehicle and infrastructure lifetime, and optimized maintenance practices.

Monitoring of weather and air quality has direct application to transportation. These examples make clear the value of low-cost, high-performance devices to make an extremely wide range of physical measurements, which can then be coupled to computer chips capable of generating

warnings or adjusting operation directly. A virtually unlimited number of physical mechanisms and sensing concepts are potentially available, but devices of special importance to transportation will be identified and brought to fruition only to the degree that the transportation community makes these needs known and establishes their potential economic and operational value.

II.4.f. Tools for Transportation Modeling, Design, and Construction

Enabling research in this area provides tools, knowledge, information, and techniques to improve dramatically the efficiency and effectiveness of (1) assessing system requirements; (2) planning and designing system improvements; (3) evaluating alternative operational concepts and strategies; (4) estimating performance characteristics likely to result from innovations; and (5) managing system operations. Specific areas of research include:

Transportation System Design Tools: Tools and methods—such as computer models and simulations and computer-aided design, integrated across all institutions involved in the planning process—that support system planning and design, including process re-engineering, with emphasis on broad system engineering and integration to assure that the resulting system makes effective use of all components in efficiently achieving a high level of performance.

Characterizing and Modeling System Performance and Impacts: Means by which system performance—such as mobility, safety, security, and economics—is measured, assessed, and integrated into system design and operation processes and decisions.

Transportation and Logistic System Operations and Management: Information technology and other tools to support operation and management of transportation and logistic systems, and to assure seamless integration across organizational, modal, and institutional interfaces.

Transportation Planning, Economics, and Institutions: Development of a broad knowledge base and identification and characterization of needs and interests of all parties involved with the transportation system; understanding the economic, financial, and institutional context for transportation.

CHAPTER 5

EDUCATION AND TRAINING

The Nation's investment in research and technology is critical to the transportation system's safety, efficiency, and capacity to support national goals. Equally important, however, is our continuing investment in the human capital, the transportation professional and worker, who is responsible for the design, construction, operation, and maintenance of the system.

The Federal Government has long supported transportation education. Current programs administered by DOT are crucial to ensuring the professional capacity of the transportation enterprise. The University Transportation Centers Program, the Eisenhower Fellowships, the Aviation Education Program, and the National Highway and National Transit Institutes are representative of the Government's continuing investment in transportation education and professional enhancement.

Through these programs, the Department supports the development of trained transportation professionals; sponsors the pursuit of promising research efforts, many of which address immediate and practical system needs; and provides a stimulus to small and minority-owned businesses capable of addressing high-priority research issues confronting transportation.

Transportation today is undergoing great change—experiencing advances in technology, undergoing organizational transformation, and continuing globalization along with the world economy. These changes require that current and future generations of transportation professionals and workers be responsive to a dynamic environment:

- *Advanced Technology:* Transportation technology once focused on traditional building materials, standard construction techniques, and combustion-engine-powered vehicles. Newly developed and deployed transportation technologies reflect advances in telecommunications, information systems, energy storage, and advanced electronics and materials. The transportation professional and worker must be educated and trained to adapt these technologies to the existing transportation infrastructure, and to take advantage of new operational practices as a means to provide capacity that, in the past, would have been added through the construction of new physical infrastructure. Moreover, these new technologies require the workforce's capacity to provide a supply of new workers, as well as train many existing workers, to operate and maintain these new systems.
- *Organizational Transformation:* The transportation organizational environment continues to change, and there is an accelerating shift away from construction of new physical facilities, and toward management practices that achieve operational efficiency gains, often through the application of information technology. ISTEA began the trend toward devolution of authority to state transportation agencies. Likewise, the movement toward

intermodal planning, finance, and operations has resulted in many highway departments evolving into state "transportation" departments. These new agencies are only now learning to address the competing needs of regional public mobility and freight movement with environmental and societal concerns. The combined impacts of devolution and transportation agency changes demand that professionals be taught the most effective and innovative management techniques.

- **Globalization:** Transportation continues to reflect a global economy. Business manufacturing and logistics chains now rely on the transportation operations and facilities of many countries. Likewise, increased world business and leisure travel requires that transportation professionals be aware of changing customer needs. For example, Japan, France, and Germany require their university transportation students to work in transportation abroad prior to graduation to provide them with a better understanding of global transportation operations.

These changes in transportation demand new initiatives to address the evolving needs of the transportation workforce. The NSTC *Transportation Science and Technology Strategy* defines four key education and training initiatives that meet the criteria listed in the accompanying box.

II.5.a. Introduction of Transportation Concepts: Elementary and Secondary Education

Transportation permeates every aspect of the nation's economy, yet little effort is made to show elementary and secondary students the connection between their studies and the transportation systems around them. Many students are lost to the transportation profession simply because they have been given no incentive to pursue subjects such as math and science that are essential to advancing in the field. Of even greater importance is the school system's responsibility to produce citizens capable of making informed choices in a democracy. We are shortchanging ourselves and our posterity when we fail to provide our young people with the knowledge of how transportation systems connect them to each other and the world. This initiative will stimulate collaborative public-private partnerships to assist educators in developing and delivering transportation education modules that are fully integrated into the curriculum for each grade level.

Criteria for Education and Training

- Build professional capacity of industry and State/local transportation agency staffs.
- Create general public awareness of transportation benefits.
- Ensure a globally competitive workforce.
- Prepare next-generation transportation professionals with multi-disciplinary education.

II.5.b. Vocational and Technical Training

Transportation has been and continues to be a major source of the nation's jobs. The need for well-trained and efficient transportation workers is crucial to the safety and competitiveness of the transportation system. This initiative supports collaborative investments with vocational schools, community colleges, and industrial training institutes to ensure a steady supply of capable workers to the transportation enterprise.

II.5.c. Transportation Degree Programs: International and Multidisciplinary

This initiative will build upon existing DOT programs to foster the development of transportation degree programs based on multidisciplinary curricula. In the face of increasing globalization of transportation, the nation's institutions of higher learning must prepare their graduates to deal with transportation as a complex issue of systems with global dimensions. This program will assist universities in their development of multidisciplinary programs focused on identifying and resolving transportation issues in an increasingly international arena.

II.5.d. Mid-Career Transportation Training

Dramatic changes in technology and organizational transformations have left many transportation professionals and workers unprepared. Where technologies and training once changed only every 20 years, today the half-life of rapidly advancing technologies may be anywhere between 3 and 5 years. Such rapid development requires that current workers and professionals be educated in the latest technological advances in ITS, diagnostics, materials, command/control systems, and related applications. Likewise, transportation agency managers require the management tools necessary to meet their new responsibilities and evolving missions. This initiative will ensure that the current generation of transportation workers and professionals has the capacity to apply the most innovative technologies and techniques.

The first part of the book is devoted to a general introduction to the subject of the history of the world. It is a very interesting and well-written book, and it is a pity that it is so short. The author has done a great deal of research, and his knowledge is shown in every page. The book is a very good introduction to the subject, and it is a pity that it is so short.

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CHAPTER 6

MEASURING SUCCESS AND ESTABLISHING FUTURE DIRECTIONS

II.6.a. Performance Measurement

Over the past several years, the use of performance measures to evaluate program effectiveness as a key feature of performance-based management has increased dramatically, both in the public and private sectors. The ongoing "re-engineering" of American business and industry has placed a premium on performance monitoring and evaluation to establish the impact of changes or restructurings. "Benchmarking" performance, both internally and against competitors, has also become a key managerial practice, as businesses endeavor to minimize unnecessary costs and maximize productivity and competitiveness, both domestically and abroad. Major decision with regard to staffing, markets, product line, expansions and R&D are now made in the presence of carefully developed and maintained performance monitoring systems, to which are tied continuously improved policies, guidelines, and procedures.

Performance-based management concepts are not new to the public sector, although they bear important differences to their private sector counterparts. In the public sector, governments and their agencies practice the concept of "planned program budgeting," where objectives are set, and budgets are allocated and programs are evaluated in relation to performance against those objectives.

The key differences in application of these principles between private and public sectors may be in the nature of the objectives and, consequently, the types of "things measured." Businesses must staunchly adhere to a "bottom-line" standard, and hence make hard decisions based on cost and profitability criteria. In the public sector, the criteria are often less clear cut. Public managers are often faced with balancing "social" objectives with physical and economic performance. These social objectives can be difficult to quantify or measure, and imply important political as well as economic tradeoffs.

Notwithstanding these difficulties, public sector performance measurement has grown significantly in the face of resource constraints, and a restructuring of public programs and organizations. The climate in which Federal programs now operate makes clear the need for increased accountability and justification of expenditures and policies.

II.6.a.i. Government Performance and Results Act

Perhaps the greatest force driving these trends in the public sector is the Government Performance and Results Act of 1993 (GPRA), P.L. 103-62, enacted on August 3, 1993. It requires the development and use of performance measures for agency management, and may ultimately provide the foundation for the use of performance measures in allocating budgets. It also requires Government-wide implementation of strategic planning, annual program goal-setting, and annual program performance reporting of expenditures in the federal budget in 1997. Agencies are to develop annual plans, setting performance goals, beginning with FY 1999. The overall schedule for GPRA implementation is shown in Table II-6-1.

The Department is currently in the process of developing its first performance plan under GPRA. This plan will identify performance goals and measures that, taken as a group and considered along with external factors, will provide valuable insight into the performance of DOT programs. However, many benefits of Federal programs take several years to be realized, and only then are the results reflected in data.

Performance goals are being developed to reflect a high-level view which cuts across the Department. More detailed goals and discussions of how goals will be achieved will be contained in performance plans developed by each of the Department's operating administrations.

The spirit and intent of GPRA is to improve Federal program effectiveness and public accountability by promoting a new focus on results, service quality, and customer satisfaction. The establishment of quantitative performance measures and goals that could be used to effectively manage resources is, however, a nontrivial task. For example, the Department's

Table II-6-1. GPRA Implementation Schedule

October 1993 Designation of agencies as pilot projects for performance plans and reports for FY 1994-1996.

October 1994 Designation of agencies as pilot projects for managerial accountability and flexibility for FY 1995-1996.

May 1997 OMB is to report to the President and Congress on the results of the pilot projects.

September 1997 Agencies submit first annual performance plans for 1999 to OMB. Before the beginning of FY 1998, all agencies are to have completed and submitted to OMB a 5-year strategic plan (updated at least every three years).

October 1997 Designation of agencies as pilot projects in performance budgeting for FY 1998-1999.

January 1998 All agencies are to prepare annual plans setting performance goals, generally expressed in "objective, quantifiable, and measurable" form, beginning with FY 1999.

March 2000 Agencies are to submit annual performance reports for FY 1999 to the President and Congress.

March 2001 OMB reports to the President and Congress on the results of all the performance budgeting pilots and recommends whether or not performance budgeting should be required.

most important strategic goal is the promotion of safe and secure transportation. There are many different potential measures of safety, each of which has specific merits and deficiencies. Examples of just three potential measures currently under consideration by the Department are shown in Table II-6-2:

Potential Measure	Pros	Cons
Per-capita transportation fatalities divided by the overall mortality rate.	Gives broad perspective on transportation facilities.	Sensitive to external changes in the U.S. mortality rate.
Average years of potential life lost before age 65 due to transportation accidents.	Magnitude of years of potential life lost to transportation accidents demonstrates the tremendous benefit to society of transportation safety programs.	Implied emphasis on preventing the untimely death of young people may not be acceptable to everyone.
Number of fatalities from transportation accidents.	Easily measured and understood, weights each life equally.	To reduce total fatalities, the transportation system will have to get safer at a faster rate than that with which its use increases.

Table II-6-2. Potential Measures for Transportation Safety

As this table indicates, the choice of measures can reflect different concerns and, perhaps, lead to important differences in policy based on the indicators used. In addition, the establishment of causality for program management can be very challenging when a wide range of policies and programs are implemented over years or decades, during which time an even wider range of external factors can influence results or outcomes.

Through initial development of an overall DOT performance plan, and the publication of a *Transportation Science and Technology Strategy*, the Administration has begun to identify broad performance goals and measures for the National transportation system. A preliminary set of measures associated with the National goals for transportation have already been identified in Table I-1. Several elements of the Department, in particular NHTSA and the ITS Joint Program Office, have identified performance measures for FY 1998 R&D programs before being required to do so under GPRA. However, many of these measures, summarized in Appendix B, are somewhat preliminary in nature, and they may not yet reflect ongoing interagency coordination processes. As such, the Department has deferred presenting them in the remainder of this section of the *Surface Transportation Research and Development Plan*.

II.6.a.ii. Indicators Applicable to Specific Phases of Inputs, Outputs, and Outcomes

Broad long-range planning documents, such as the NSTC *Transportation Science and Technology Strategy* and this *Surface Transportation Research and Development Plan*, emphasize long-term societal goals such as a safer transportation system. Progress toward such goals is measured using broad system-level indicators, an example of which, in this case, might be the total annual number of transportation-related fatalities. It must, however, be understood that progress toward ultimate outcomes results from the combined effects of research, implementation, and external factors. More specific indicators of performance are required at the program level, and these indicators must flow from the system-level goals through a series of intermediate measures.

In *Assessment of Fundamental Science*, NSTC has identified several principles for the assessment of fundamental science programs--these principles are also of value in the initial consideration of applied research that is more typical of transportation R&D. These principles include:

- Clear definition of program goals.
- Development of criteria intended to sustain and advance the excellence and responsiveness of the research system.
- Establishment of performance indicators that are useful to managers and encourage risk taking.
- Avoidance of assessments that would be inordinately burdensome or costly or that would create counterproductive incentives.
- Incorporation of merit review and peer evaluation of program performance.
- Use of multiple sources and types of evidence; for example, a mix of quantitative and qualitative indicators and narrative text.
- Production of assessment reports that will inform future policy development and subsequent refinement of program plans.
- Communication of results to the public and elected representatives.

This report also defines several general categories of performance measures, summarized below in Table II-6-3:

Quantitative	Qualitative
Publication Counts	Merit Review with Peer Evaluations
Patent Counts	International Standing
Citation Counts	
Contributions to Other Goals	
Rate-of-Return, Other Economic Measures	

Table II-6-3. General Categories of Performance Measures for Research

For transportation research and development, performance measures that fall into these general categories are of use in assessing specific programs. However, because many of those programs are more directly oriented toward intermediate and ultimate outcomes, consideration of a wider range of hierarchical performance measures is critical for transportation R&D.

II.6.a.iii. Framework for Measuring the Performance of Transportation R&D

In its *Transportation Science and Technology Strategy*, the NSTC CTRD has developed a tiered approach to planning transportation R&D, which is presented above in Chapter 2. This approach organizes the different realms of research into groups which produce a logical sequence of outputs and inputs--some activities producing outputs that are, in turn, inputs to subsequent activities. This sequence, through interactions with external factors, results in a set of intermediate and ultimate outcomes. Within the context of transportation research and development, this model is illustrated in somewhat more detail below in Figure II-6-1.

As this figure demonstrates, any specific R&D project draws upon a range of resources, and produces research outputs (e.g., technologies), which in turn, can result in outcomes at subsequent stages through subsequent activities. In order to be effective as management and planning tools, performance measures must be appropriate to the hierarchical level at which they are applied:

- At a high level, performance goals and indicators must be established for ultimate outcomes related to the National transportation system.
- For project planning and management, considerably more direct measures of program outputs are needed.

- These program outputs need to be linked to intermediate and ultimate outcomes through a well-chosen series of intermediate measures.

As discussed below, the Department is currently developing measures at all three levels as part of the budget planning process for fiscal year 1999.

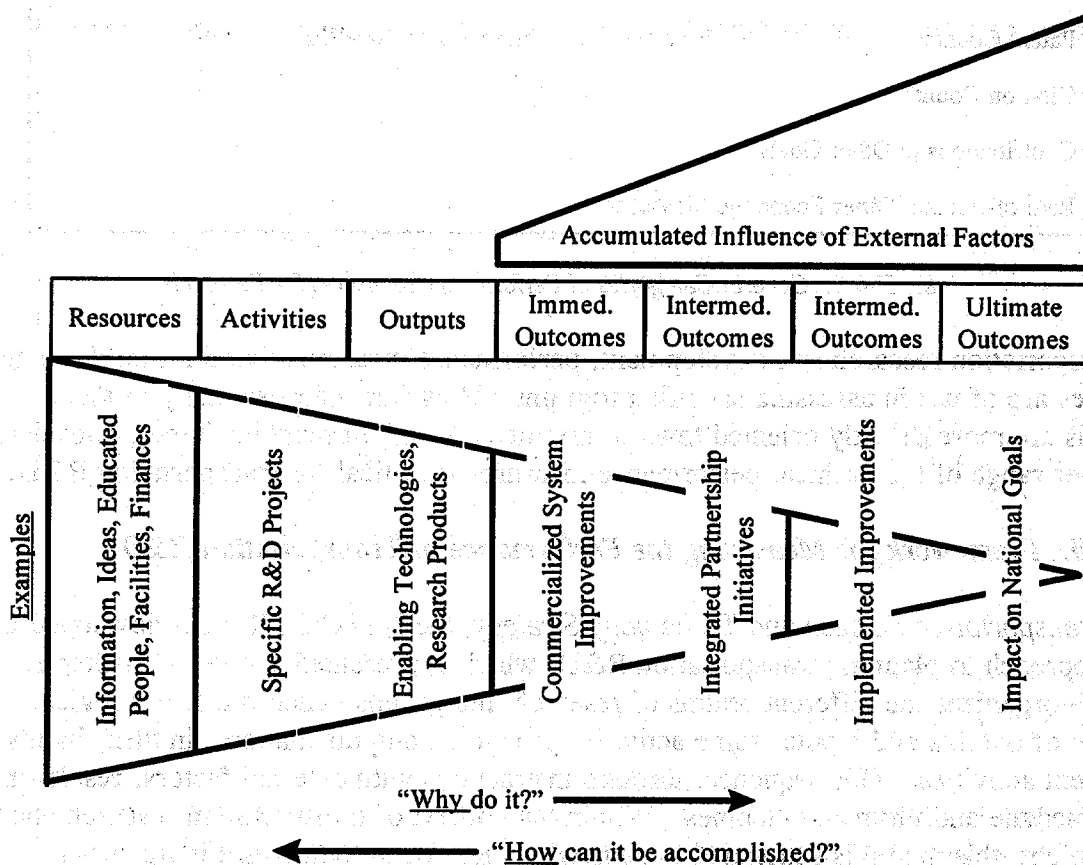


Figure II-6-1. Logical Model for Programs and Outcomes

II.6.a.iv. Research and Development Contribution to Top-Level Goals

In the above-mentioned strategy document, the NSTC CTRD has identified five potential general measures which apply to the National goals for the transportation system, as presented below and in Table I-1.

These high level measures of what are, from a transportation perspective, ultimate outcomes, provide a very general indication of the overall performance of the National transportation system. They apply to all modes of transportation, and to the system as a whole. The focus of this report is on surface transportation only. These measures have a great deal of integrating power--that is, they measure the combined results of both DOT's programs and the

full range of external factors, and involve measurement beyond the transportation sector. By the same token, they have very little resolving power, and would be of little use as measures of success of any specific R&D program.

<u>Strategic Goal</u>	<u>Outcome Measure</u>
Provide a safer transportation system.	Level of reduction in transportation-related fatalities, injuries, and property losses.
Achieve a high level of transportation system security.	Level of public trust and confidence in the security of the Nation's transportation network as determined through national surveys.
Improve environmental quality and energy efficiency.	Number of major areas not now attaining legislatively-mandated air quality standards that reach these air quality goals by 2020.
Foster economic growth and productivity through global passenger and freight services.	Level of cost-effective passenger and freight throughput.
Ensure improved access to and increased mobility on the Nation's transportation system.	Degree of increased and enhanced access and mobility of the elderly, the poor, and other transportation-disadvantaged populations.

Table II-6-4. National Strategic Goals and Measures for Transportation

The Department is currently considering a wide range of more specific--for example, with respect to mode--potential performance goals and measures applicable to the transportation system, to be used in budgetary planning for fiscal year 1999, per GPRA. In doing so, the Department is following a number of related guiding principles, examples of which include:

- Outcomes are always influenced by external factors beyond the program's or agency's control--performance goals and indicators must reflect how agencies will strive to influence these elements not entirely in their control.

- Goals must be stated in terms that are clearly understandable to one's "next door neighbor."
- Goals must be externally focused--the unique things programs do that provide value to the public.
- Goals must be clearly linked to mission.
- Goals should be ambitious, but realistic.
- Outcome goals should be independent of how they will be achieved.
- Goals and measures are part of a bigger communication process. Communicating the value of programs in terms which are ultimately comparable with other Federal programs will allow high-level decision makers to set government-wide priorities.
- Performance measures must be relevant to senior management, and usable in managing activities and resources.
- Measures must be credible externally--including credible data and a credible program evaluation process.
- Imperfect measures are acceptable. The process is evolutionary.

The Department is currently examining nearly fifty different candidate measures of performance of the National transportation system. In doing so, DOT must consider the degree to which potential measures adhere to the above principles, and must weigh the policy issues, such as that shown in Table II-6-2, which are inherent in the choice of measures. An illustrative and noninclusive list of candidate measures follows:

Performance Aspect	Sample Measure
Accessibility--Coverage	Highway system supply (lane miles, by classification, condition, etc.) per "demand unit" (capita, employee, square mile, VMT)
Accessibility--Proximity	Percent of potential passenger travelers within x miles or y minutes of specified transportation service (interstate/4-lane highway; local public transit service; intercity bus or rail service; scheduled air service)

Accessibility--"Realistic" or "Functional" Access	Number of persons who can reach a specified destination (local, intercity, international) by applicable mode (transit, intercity bus or rail, scheduled) within specified limiting service parameters (e.g., no more than 1 transfer, no more than x hours/minutes of delay, no more than y% circuitry)
Quality of Service--Level of Service	Percent of highway lane miles with peak hour volume to capacity (V/C) ratios > 0.9; Change in percent of lane miles which are at V/C > 0.9 (1) outside peak periods, and (2) for expressway facilities
Quality of Service--User Satisfaction	Passenger assessment of level of quality/satisfaction and/or degree of change in: travel time, speed, cost, number of alternatives, congestion, reliability, safety, etc.
Quality of Service--Efficiency	Carrying efficiency of passenger modes (private vehicle persons per vehicle mile; transit passengers per seat-mile, intercity air, rail, bus load factors)
Economic Health and Competitiveness	Cost of transportation reflected in final cost of goods and services (transportation CPI vs. manufactured goods CPI)
Social Equity, Mobility, Quality of Life	Percentage of day devoted to traveling for persons, households
Security	Number of incidents (terrorism, hijackings, theft, vandalism) associated with transportation activities per utilization unit (e.g., per capita, per person-trip, per service operation, per dollar of travel/shipment expenditure, etc.)
Safety	Number of transportation accidents, injuries, fatalities per "demand unit" (e.g., per person-trip, passenger mile, VMT, type of facility, major mode)
Environment	Emissions rates of transportation modes (passenger vehicles, transit, air, rail, freight, modes), current year/models and fleet average
Energy	Fuel consumption rates (mpg or Btu per mile) of transportation modes (passenger and freight), current year and fleet average

Table II-6-5. Sample Performance Measures for the National Transportation System

Over the next several months, the Department will be choosing from these and other performance measures to develop a set that will be the most useful for initial performance-based budget planning.

II.6.a.v. Intermediate Measures

In preparing its fiscal year 1999 budget, the Department will face three fundamental challenges in making explicit its performance-based management of scarce public resources. It must establish a set of overall goals for the performance of the National transportation system, and identify a set of indicators of progress toward those goals. It must begin to identify intermediate measures of performance which, for a given program, go beyond the direct outcomes of that program, but are also less subject than the high-level performance indicators for the transportation system as a whole to the influence of factors external to that program. Finally, the Department must identify means by which the performance of individual programs, including R&D programs, can be measured.

In the example given below in *II.6.a.vi*, a yearly assessment of the extent to which NHTSA's Crash Avoidance Research program has accelerated the development of crash avoidance products by the private sector provides just such an intermediate measure of performance. A major focus for the next several months will be the identification of such measures for the range of the Department's research programs.

II.6.a.vi. Measurement of Outputs

In some ways similar to that resulting from basic research, the knowledge gained through the applied research that is more typical of transportation R&D is not always of immediate value, and is not always applied immediately. For example, a research program may yield a technology which has the potential to prevent a specific type of transportation accident, but the deployment of that technology could be limited by policy considerations (i.e., regulatory agenda) and/or market conditions. As a result, performance measures for transportation R&D may be expressed in terms of direct outputs and more intermediate outcomes.

For example, in its *FY 1995 Performance Report* (March 1996), NHTSA, which was chosen by OMB as a GPRA pilot, identified the following measures for its Crash Avoidance Research: (1) timely dissemination of research results, (2) timely response to short-term rulemaking needs, and (3) acceleration of private sector development of crash avoidance products. Obviously, the ultimate objective of NHTSA's Crash Avoidance Research is the prevention of specific types of collisions--however, these measures of direct outcomes (1 and 2) and intermediate impact (3) will give a much more direct measure of performance of the research program itself.

Initial efforts by DOT operating administrations to develop performance measures for transportation R&D programs have, in general, yielded measures that fall into the general

categories identified in the NSTC report on *Assessment of Fundamental Science*, or are similarly specific to direct program outputs. In many cases, R&D programs have also been linked to high-level outcomes they are designed to influence. Appendix B presents a detailed list of preliminary performance measures developed to date by DOT for its R&D programs.

II.6.b. Summary

Strategic planning and assessment--the basis for efficient utilization of scarce public resources--must be pursued on an ongoing basis, and must be founded upon an evolving process for measuring both progress toward ultimate societal goals and performance of specific funded programs. With respect to surface transportation research and development, multi-sectoral and multi-modal top-level outcomes, which can be measured by high-level performance indicators, are the result of technologies and systems that are actually implemented as part of the National transportation system. In the future, such technologies and systems, whose success can be measured by outcome indicators that tend to be somewhat more specific and modally-oriented, will increasingly be developed through partnerships that capitalize on opportunities for private/public resource leveraging. These technologies and systems will be founded upon an enabling technology base that is established and enhanced on a long-term basis, and progress in doing so will be measured both in terms of direct technological outputs and, in some cases, intermediate outcomes. A technologically capable workforce will be a key resource input at this and all higher levels, and success in providing this resource will be measured as a direct output of education and training. Only by committing to regularly measure progress at all levels and conduct strategic program planning and assessment can the Nation ensure the most efficient and effective possible utilization of its resources for surface transportation research and development.

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

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SECTION III

NEAR-TERM PLAN FOR SURFACE TRANSPORTATION RESEARCH AND DEVELOPMENT

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CHAPTER 1

NEAR-TERM SURFACE TRANSPORTATION RESEARCH: INTRODUCTION

Relationship between Future Plans and Current Activities

In sections I and II of this report, the Department has presented a four-tiered approach to the shaping and implementation of surface transportation research, consisting of the following elements:

- Strategic Planning and Assessment to establish a research framework that embodies National Goals for the transportation system and establishes associated measures of transportation system performance which can be used to prioritize and evaluate related research programs. In sections *II.2.d.i* and *II.6.b*, the report discusses the need for an ongoing commitment to strategic planning of transportation R&D informed by evolving measures of performance.
- Strategic Partnership Initiatives that focus on the aggressive exploitation of rapidly evolving technological opportunities and the introduction of innovative equipment and operations into the transportation enterprise, through leveraging of multi-agency and public/private resources. Chapter *II.3* identifies twelve such partnerships, ten of which relate to surface transportation.
- Enabling Research in areas that support long-term transportation goals and contribute to long-term innovation and offer significant impacts affecting many modes of transportation, but have benefits too, diffuse, uncertain, or far in the future to motivate sufficient private sector investment. Chapter *II.4* presents six enabling research areas which will be particularly important for transportation, and relates these to the Department's previously-stated long-term objectives for surface transportation R&D.
- Transportation Education and Training to assure the continued availability of the highly-qualified transportation professionals and workers upon whom depends the design, construction, operation, and maintenance of the Nation's transportation system, ultimately determining its safety and performance. Chapter *II.5* address the need for training initiatives relevant to mid-career education, vocational training and education, and international transportation curricula building.

The body of activities presented in Section II, which is based upon the recently completed NSTC *Transportation Science and Technology Strategy*, has important relationships to surface transportation research currently conducted with DOT. However, although they in many ways support and enhance ongoing research related to fundamental DOT responsibilities discussed above in *II.2.e*, it must be recognized that these statutory responsibilities require a broad base

of research activities, not all of which can be neatly aligned with a specific initiative or area of long-term enabling research. The elements of Section II call attention to focused areas of unique opportunity. To the extent that these elements arise from and/or support the Department's current research activities, the relationships are indicated in general terms in Table III-1-1.

Program Title	1	2	3	4	5	6	7	8	9	10	11	12	A	B	C	D	E	F	Educ./ Training
Federal Highway Administration (FHWA)																			
Highway Safety																			
Pavement Research Program																			
Structures Research Program																			
Environmental Research																			
Right-of-Way Research Program																			
Policy Research																			
Transportation Planning Research																			
Motor Carrier Research																			
ITS -- Research and Development																			
ITS -- Adv. Veh. Control and Info. Systems																			
ITS -- Architecture and Standards																			
ITS -- Operational Tests																			
ITS -- Evaluation																			
ITS -- Mainstreaming																			
ITS -- Program Support																			
ISTEA Section 6058 Funds																			
Technology Assessment and Deployment																			
National Advanced Driver Simulator																			
Local Technical Assistance Program																			
Fairbank Building Renovation																			
National Highway Institute																			
University Transportation Centers																			
University Research Institutes																			
State Planning & Research Program																			
Strategic Highway Research Program Implementation																			
Eisenhower Transportation Fellowship Program																			
Applied Research & Technology																			
Seismic Research & Development Program																			
Timber Bridge Research Program																			
GPS Support																			

***Priority Strategic Partnerships**

1. Smart Vehicles and Operators
2. National Intelligent Transportation Infrastructure
3. Next-Generation Global Air Transportation
4. Enhanced Transportation Weather Services
5. Enhanced Goods and Freight Movement at Domestic and Int'l Gateways
6. Accessibility for Aging and Transportation-Disadvantaged Populations
7. Local Environmental Assessment Systems
8. Next-Generation Motor Vehicles and Ships
9. Aviation Safety Research Alliance
10. Total Terminal Security
11. Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure
12. Environmental Sustainability of Transportation Systems

****Enabling Research Areas**

- A. Human Performance and Behavior
- B. Advanced Materials
- C. Computer, Information, and Communications Systems
- D. Energy and Environment
- E. Sensing and Measurement
- F. Tools for Transportation Modeling, Design, and Construction

■ = strong relationship
 ■ = partial relationship

Table III-1-1. Relationships between Near-Term R&D Plans, Partnership Initiatives, and Enabling Research.

Program Title	Priority Strategic Partnerships*												Enabling Res. Areas**						Educ./ Training
	1	2	3	4	5	6	7	8	9	10	11	12	A	B	C	D	E	F	
FHWA (cont'd)																			
Research & Technology Technical Support																			
Administration																			
National Highway Traffic Safety Administration (NHTSA)																			
Safety Systems																			
Biomechanics																			
Partnership for a New Generation of Vehicles																			
Crash Avoidance--Driver/Vehicle Performance																			
Heavy Vehicles																			
Fatal accident reporting system (FARS)																			
National Accident Sampling System (NASS)																			
Data Analysis																			
State Data Program																			
Occupant Protection Survey																			
Special Crash Investigations																			
Technology Transfer Programs																			
Vehicle Research and Test Center																			
Highway Safety Research																			
Administration																			
Federal Rail Administration (FRA)																			
Equipment, Operations & Hazardous Materials Research																			
Track Structures and Train Control																			
Safety of High Speed Ground Transportation																			
R&D Facilities																			
Administration																			
Next Generation High-Speed Rail																			

***Priority Strategic Partnerships**

1. Smart Vehicles and Operators
2. National Intelligent Transportation Infrastructure
3. Next-Generation Global Air Transportation
4. Enhanced Transportation Weather Services
5. Enhanced Goods and Freight Movement at Domestic and Int'l Gateways
6. Accessibility for Aging and Transportation-Disadvantaged Populations
7. Local Environmental Assessment Systems
8. Next-Generation Motor Vehicles and Ships
9. Aviation Safety Research Alliance
10. Total Terminal Security
11. Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure
12. Environmental Sustainability of Transportation Systems

****Enabling Research Areas**

- A. Human Performance and Behavior
- B. Advanced Materials
- C. Computer, Information, and Communications Systems
- D. Energy and Environment
- E. Sensing and Measurement
- F. Tools for Transportation Modeling, Design, and Construction

■ = strong relationship
 ■ = partial relationship

Table III-1-1 (cont'd). Relationships between Near-Term R&D Plans, Partnership Initiatives, and Enabling Research.

Program Title	Priority Strategic Partnerships*												Enabling Res. Areas**						Educ./ Training
	1	2	3	4	5	6	7	8	9	10	11	12	A	B	C	D	E	F	
Maritime Administration (MARAD)																			
Industry Competitiveness																			
Intermodal Development																			
Maritime Safety																			
Shipyard Revitalization																			
National Security Administration																			
Federal Transit Administration (FTA)																			
New Bus Vehicles and Infrastructure																			
Advanced Bus Propulsion Systems																			
New Rail Vehicles and Infrastructure																			
Transit Services Management Innovation																			
Rural and Specialized Transportation																			
Metropolitan / Rural Policy Development																			
Planning and Project Development																			
Safety and Security																			
Human Resources																			
Transit Cooperative Research Program																			
National Transit Institute																			
University Transportation Centers																			
Rural Transit Assistance Program																			
Administration																			
Research and Special Programs Administration (RSPA)																			
Hazardous Materials Research																			
Pipeline Safety Research																			
Research and Technology																			
Emergency Transportation																			

***Priority Strategic Partnerships**

1. Smart Vehicles and Operators
2. National Intelligent Transportation Infrastructure
3. Next-Generation Global Air Transportation
4. Enhanced Transportation Weather Services
5. Enhanced Goods and Freight Movement at Domestic and Int'l Gateways
6. Accessibility for Aging and Transportation-Disadvantaged Populations
7. Local Environmental Assessment Systems
8. Next-Generation Motor Vehicles and Ships
9. Aviation Safety Research Alliance
10. Total Terminal Security
11. Monitoring, Maintenance, and Rapid Renewal of the Physical Infrastructure
12. Environmental Sustainability of Transportation Systems

****Enabling Research Areas**

- A. Human Performance and Behavior
- B. Advanced Materials
- C. Computer, Information, and Communications Systems
- D. Energy and Environment
- E. Sensing and Measurement
- F. Tools for Transportation Modeling, Design, and Construction



 = strong relationship
 = partial relationship

Table III-1-1 (cont'd). Relationships between Near-Term R&D Plans, Partnership Initiatives, and Enabling Research.

Presentation of DOT Near-Term R&D Plans

The Department's near-term plans for its surface transportation research and development are presented in detail in the remainder of this section, which retains the organizational structure used in the third edition of this report. The NSTC Committee on Transportation Research and Development has identified R&D priorities in the following broad elements of the transportation enterprise

- Physical Infrastructure for Transportation
- Information Infrastructure for Transportation
- Next-Generation Transportation Vehicles
- Human Performance in the Transportation System
- Transportation System Assessment Tools and Knowledge

These general categories are used in Section III as a structure for near-term R&D planning. To this structure, the Department has added the following two elements which cut across the above five categories, and enhance the Nation's ability to achieve gains in these areas:

- DOT Investment in University Research, Education, and Cooperative Activities
- DOT R&D Facilities and Administrative Support for R&D

The chapters devoted to these areas provide notation indicating which of the five NSTC categories cover specific programs in these two areas. It should be noted that many of the Department's R&D programs make important contributions to progress in more than one of the above categories. For purposes of this report, each program is presented in the chapter addressing the area to which that program contributes to the greatest relative degree.

For each planned research program, a description is presented with key milestones and budget and staffing data. The table entry "NA" is used to indicate cases in which information was not available at the time of publication. The format used is as follows:

Program Title (Lead Administration)

FY	1997	1998	1999
Funding	in \$thousands for each fiscal year		
FTE	in full-time-equiv. for each fiscal year		

Program description, with key milestones for fiscal year 1998.

CHAPTER 2

PHYSICAL INFRASTRUCTURE

Most of us take America's superb transportation physical infrastructure for granted--our roads, railroad tracks, transit systems, airports, railroad terminals, bridges, tunnels, and navigable waterways are unmatched in all the world. However, as stated in the Clinton Administration's technology policy, *Technology for America's Economic Growth, A New Direction to Build Economic Strength*, "...one of the greatest challenges we face is to rehabilitate and maintain the huge stock of infrastructure facilities already in place."

Infrastructure renewal is also a core element of the Department's *Strategic Plan*. DOT is committed to achieving the goal of a coherent and interconnected multimodal National Transportation System. As stated in the plan: "transportation infrastructure strengthens America by bringing people and communities closer together, spurring trade and commerce to meet the new demands of a global economy...Our challenge now is to shift our attention from what we've built to how we can make it work better for our country - through the adaptation and modernization of our existing infrastructure." In response to the Administration's identification of transportation infrastructure renewal as a National priority area, the NSTC Committee on Transportation R&D endorsed the President's four major transportation physical infrastructure strategic R&D goals:

1. *Develop technologies, advanced materials and methods to efficiently maintain and renew the aging transportation infrastructure.*
2. *Improve existing infrastructure performance (Lifecycle cost, environmental impact, service life, traffic capacity, safety).*
3. *Develop and expand technology base for innovative vehicles and systems and for intermodal integration.*
4. *Enable efficient infrastructure emergency response and quick recovery after disasters.*

In addition, the Committee has identified a number of crossmodal and generic R&D priority thrusts. These include:

1. *Nondestructive Test, Inspection and Evaluation, diagnostic sensors, technologies and modeling tools*
2. *High performance materials*

3. *Automation and robotics for renewal engineering*
4. *Emergency response technologies (e.g., seismic damage repair)*
5. *Intermodal hazards reduction (e.g., highway/rail and transit crossings)*
6. *Tools for infrastructure maintenance and prioritization management*

The current US transportation infrastructure includes 3.9 million miles of roads; 575,000 bridges, 180,000 miles of railroad track, 11,000 miles of urban rail, 1,264,000 miles of natural gas pipelines, 26,000 miles of navigable waterways, and airports and seaports. The United States' 3.5 million miles of surfaced roads carry one-third of the ton-miles of domestic freight and nearly 90% of passenger-miles traveled. High-performance airports are central to long-distance public transportation. Public expenditures for construction and maintenance of the highway system alone, derived largely from direct user fees as well as non-user-based tax revenues, are approximately \$80 billion per year, requiring a workforce of about 800,000 people.

Obtaining the best life-cycle performance from America's surface transportation infrastructure is thus of great importance not only to users, but also to government at all levels. The Department's 1995 *Status of the Nation's Surface Transportation System: Conditions and Performance Report to Congress* is the latest in a series of biennial reports that track changes in transportation physical and operating characteristics, finance, and usage patterns. The report finds that personal and freight demands on our systems are at an all time high and are expected to increase with population and economic growth, but at a slower rate than in past decades.

Although this *Surface Transportation Research and Development Plan* focuses on surface infrastructure research (highways, transit and rail facilities, pipelines, ports), there are areas in which coordination with aviation infrastructure research will be increasingly important. For example, market shifts toward very large aircraft are making it necessary that runway surfaces be upgraded to endure the forces associated with these heavy planes--even though there are important differences in loading characteristics, coordination between FHWA and FAA on pavement materials research will be important to ensure the widest possible application of improvements in this area.

Near Term Efforts

Emphasis in the area of surface transportation physical infrastructure research is on technologies and procedures associated with: operational efficiency, durability, performance, safety, environmental impacts, renewal and maintenance, real-time nondestructive inspection and monitoring of infrastructure condition and performance; improved design and construction concepts and practices, processes, structures, materials, resource use, and disposal of

construction process wastes, recycling and reuse of byproduct and waste materials, as well as design and construction principles and technologies specifically relevant to intermodal connection points. The surface transportation programs that have physical infrastructure as their major focus are listed below and described in the paragraphs that follow:

Highway Safety (FHWA)

FY ⁴	1997	1998	1999
Funding	8,650	9,000	NA ⁵
FTE	22.8	22.8	NA

FHWA continues to focus on improving the safety of the highways in the United States. Great advances have been made in the last 20 years but more needs to be accomplished to reduce the more than 40,000 fatalities, 3 million injuries, and \$100 billion in economic loss incurred annually due to highway crashes. The FHWA safety research program is directed at improving both the design features of the roadway, and traffic control systems so drivers of all ages can use the highway system in the safest and most productive manner. The research program focuses on driver and pedestrian decision behavior and the highway features such as traffic management, traffic control devices, highway design geometry, signage, markings, and environmental conditions. Current research efforts include:

- Night Visibility Enhancement - Over half of all highway fatalities occur during the hours of darkness. FY 1997 is the first year of a 3-year funded consortium project of private and public participants to address: the impact on highway safety, durability of fluorescent materials, preliminary cost/benefit analysis, feasibility of more efficient UV light sources, health and environmental considerations, installation and maintenance costs, manufacturing and marketing problems, infrastructure issues, implementation strategies, and how the concept can be meaningfully demonstrated.
- Highway Safety Information Management - The highway safety information management program will develop high quality, easily accessible highway safety information systems and provide the technology and analytical tools for the analysis of highway safety problems. The FY 1997 program will provide for the continued improvement and operation of the Highway Safety Information System (HSIS). This effort will include development of supplemental roadway and traffic volume files; full incorporation of advanced technologies such as pen-based computers and GPS receivers; and significant improvements to methodologies for problem identification and safety analysis. The

⁴Throughout Section III, funding levels for each fiscal year are expressed in thousands of dollars, and staffing levels are shown as Full-Time-Equivalents (FTE).

⁵Not available at the time of publication.

program will also include an evaluation of administrative, technological, and analytical improvements to the design and operation of state accident and roadway data systems.

- **Interactive Highway Safety Design Model** - The objective of the IHSDM program is to develop a series of interactive computer programs that will enable highway designers and design reviewers to assess the potential safety effects of specific geometric design decisions. Vehicle Dynamics, Driver, Accident Analysis, Traffic, and Policy modules are being developed to allow examination of the entire roadway design including the roadway alignment, the roadway cross-section, and the roadside. Full implementation will occur as these modules are integrated into commercially-available computer aided design (CAD) packages. Where appropriate, funds are being leveraged by conducting research in conjunction with the National Cooperative Highway Research Program (NCHRP).
- **Roadside Safety Hardware** - In 1995, run-off-the-road crashes resulted in 8,000 deaths and estimated societal costs of more than \$38 billion. The objective of this research effort is to reduce the severity of run-off-the-road crashes by developing crashworthy roadside safety hardware and other roadside features that can effectively accommodate a diverse vehicle fleet. The research is focused on the development of advanced computer simulation techniques that will reduce the need to rely on crash tests alone and will allow evaluation of safety hardware for a wide range of vehicle types and impact conditions. To insure that the roadside hardware and the vehicles are treated as a "design system", this research program is coordinated closely with NHTSA.
- **Pedestrian and Bicyclist Safety** - Crashes involving pedestrians and bicyclists account for more than 15% of traffic fatalities. This effort is in support of the Department's National Bicycling and Walking initiative, which aims to safely accommodate increased numbers of pedestrians and cyclists in the highway environment. The goals of the program are (1) to double the current percentage (7.9%) of total trips made by bicycling and walking, and at the same time, (2) to reduce by ten percent the number of bicyclists and pedestrians killed or injured in traffic crashes. This program will develop improved planning techniques, new methods for identifying problem locations, innovative engineering countermeasures, and training tools to guide users in the implementation of improved pedestrian and bicycle facilities.
- **Human Factors Research for Highway Safety and Intelligent Transportation Systems** - The goal of this program is to increase highway safety by improving the compatibility between drivers (including commercial vehicle operations), basic highway design functions, traffic control devices, and smart technologies to enhance highway safety, traffic control centers and traffic flow. The primary current research areas include: updating the Older Driver Handbook; investigating driver response to traffic control devices and other safety countermeasures; and evaluating the influence of highway design on driving behavior.

- **Engineering Improvements for Enhanced Safety and Operations** - Growth in traffic and congestion is causing a shift from arterials onto local roads, where speed and conflicts with nonmotorists are major concerns. The aim of this research is to identify, develop, and test engineering measures to safely and effectively manage speed, increased traffic, driver decisions, traffic control, and nonmotorists consistent with the function and use of different road facilities.

Major milestones for fiscal year 1998 will include:

- Beta testing of selected IHSDM modules through cooperative agreements with State DOTs and/or design consultants.
- Standardized software for analyzing crash test data and preparing test reports. This software will help to promote international harmonization of testing standards.
- Completion of a study assessing bicycle safety countermeasures.
- Simulation and field study evaluation of the effects of geometry and environmental factors on drivers' selections of headway, in order to identify those countermeasures that are the most effective in helping drivers to maintain proper headway.
- Enhancement of network traffic simulation models to evaluate the effect on delay and conflicts of innovative intersection designs such as jug handles and continuous flow intersections, for a range of traffic conditions.

Pavement Research Program (FHWA)

FY	1997	1998	1999
Funding	13,731	11,150	NA
FTE	24	24	NA

The goal of the FHWA Pavements Research Program is to develop more cost-effective and better-performing pavements. The development of these technologies is an evolving process which includes three stages of utilization: current practices, best practices, and state-of-the-art practices.

Although there are significant differences in the typical loading profiles (e.g., longitudinal motion of multi-axle line-haul trucks compared to rapid vertical motion of much heavier aircraft), FHWA works closely with FAA on the improvement of pavements. FAA is currently seeking partners to share the cost of building a pavement test facility that would enable testing of new pavements, and the identification of the best possible replacements at

airports where heavier new transport and cargo aircraft pose a particular problem for runway deterioration.

FHWA's Pavement Research Program is currently divided into three major focus areas:

- **Pavement Management** - Continuing efforts are being made to implement protocols or pavement condition data collection and analysis, and to develop nondestructive pavement evaluation technology.
- **Quality Improvements** - Continuing efforts are being made to validate the Superpave mixture design and analysis systems; to develop performance-related specifications; to develop guidelines for crumb rubber modified (CRM) asphalt pavement design and construction; to investigate alkali-silica reaction (ASR) potential in existing Portland cement concrete (PCC); to develop the use of high performance concrete in pavement applications; and to support Superpave performance models management, WesTrack, and the AASHTO Materials Reference Laboratory (AMRL).
- **Long-Term Pavement Performance** - The largest pavement performance research project ever undertaken, the 20-year LTPP research encompasses 2,600 in-service pavement test sections, and includes two sets of experiments: the General Pavement Studies (GPS) and the Specific Pavement Studies (SPS). The LTPP data base will serve as a critical resource for pavement performance research and will yield improved pavement performance model and design procedures.

Major FHWA pavement research milestones planned for fiscal year 1998 will include:

- LTPP data analysis will yield 8 to 10 specific pavement quality enhancements.
- Results from the tire footprint pressure study.
- Guidelines for CRM asphalt pavement design and construction.
- Modeling of load transfer in PCC pavements.
- Pavement performance models for new pavement designs.

Structures Research Program (FHWA)

FY	1997	1998	1999
Funding	14,362	15,256	NA
FTE	15	15	NA

FHWA's Structures Research Program strives to obtain (1) measurable improvement in the life cycle costs of US highway structures built after 2005 and (2) observable inspection and maintenance cost savings or extensions of services life in all common types of existing structures without degradation of highway safety or the environment.

Specific current objectives include:

- Research on the physical and chemical characteristics of new high-performance materials so as to develop definitive criteria and guidelines for their use in the repair, rehabilitation, and construction of bridges.
- Improvements to the reliability, speed, and user-friendliness of nondestructive evaluation (NDE) methods for quality control during construction; improvements to the ability to detect hazardous conditions during bridge inspections; development of reliable, fast, and efficient global NDE for bridge monitoring; and development of new technologies and techniques for integrating quantitative NDE into bridge management systems.
- Finding better means for assessing the vulnerability of bridges to seismic and other natural forces; developing improved guidelines and design criteria for the design and construction of bridges to resist these forces; and developing improved methods of retrofitting existing structures against natural hazards.
- Conducting higher-risk exploratory research to investigate new techniques for nondestructive characterization of materials.

Major FY 1998 milestones will include:

- Durability testing, design criteria guides, and surface-preparation guides for interfacial adhesive behavior of structural adhesives.
- Completed construction of FHWA's facility (i.e., a bridge) with known signatures that can be used to test, evaluate, and calibrate NDE equipment.
- Technical guidance for determining the response and design of miscellaneous highway structures under wind load and vibration.

- Study of new techniques for measuring fatigue in aging steel, for acoustic microcrack detection, and for measurement of steel corrosion in reinforced concrete.
- Construction of at least 50 bridges utilizing high-performance materials.

Environmental Research (FHWA)

FY	1997	1998	1999
Funding	5,443	5,566	NA
FTE	5.0	5.0	NA

FHWA's Environmental Research Program addresses highway impacts on air quality, wetlands, water quality, hazardous waste sites, communities, aesthetics, and noise. The goals of the environmental research program include: better capability to understand and predict the impacts of highway transportation systems on the natural environment, cultural resources, and the local community; development of methods to avoid and mitigate those impacts and enhance the environment; the integration of environmental considerations into the system planning and project development processes in a cost effective manner; and share innovations with FHWA partners in State and local governments. The major current research areas include:

- Air Quality - Assisting States and Metropolitan Planning Organizations (MPOs) with meeting Clean Air Act requirements by providing improved analysis methodologies, and information on the relationship of transportation programs and emissions on air quality levels.⁶ Assisting EPA in its efforts to develop a new and more accurate mobile source emissions model.⁷ Examining the impacts on the transportation program, and the additional control strategies that are necessary, resulting from new and tighter National Ambient Air quality Standards for ozone and fine particulate matter.
- Wetland Resources - Developing methods to delineate, identify, restore, and protect existing wetlands, and identifying innovative wetlands restoration and creation projects around the nation.
- Water Resources - Updating research on highway storm water runoff to account for new highway construction techniques, new motor fuel constituents (e.g., MTBE), changes in engine emissions, and new vehicle components.
- Environmental Process - Providing training and technical assistance to facilitate effective implementation of the FHWA National Environmental Policy Act (NEPA) process.

⁶Discussed further in Chapter 6, under the description of FHWA's Transportation Planning Research.

⁷Discussed further in Chapter 6, under the description of FHWA's Transportation Planning Research.

- Community Impacts and Public Involvement - Evaluating policy, procedural, technical, and legal issues associated with community impact assessment and mitigation options and evaluating data needs, assessment techniques, and methodologies to allow for the efficient determination of community dynamics and impacts of proposed transportation projects.
- Historic and Archeological Preservation and Aesthetics - Providing tools necessary to meet technical and procedural requirements related to the preservation of historic and archeological resources, identifying highway maintenance practices which can benefit visual quality such as the use of wildflowers and other native plant species.
- Highway Traffic Noise - Developing technology transfer resources that address advancements in construction noise measurement, analysis, and abatement.

Major fiscal year 1998 milestones will include

- Documentation and evaluation of the effectiveness of transportation programs that are initiated to meet mobile source emissions budgets.
- Completion of a Mitigation Manual for Estuarine Wetlands.
- Publication of an evaluation of ultra-urban best management practices for controlling storm water runoff from highways.
- Consideration of the impacts of current technology such as ITS on the social, environmental, and economic impacts of a transportation project.
- Identification of state-of-the-art predictive methodology for dynamic social characteristics/factors.
- Publication of design standards for the rehabilitation and preservation of historic highway bridges.
- Development of a videotape which addresses noise-compatible land use planning.

Right-of-Way Research Program (FHWA)

FY	1997	1998	1999
Funding	322	365	NA
FTE	0.25	0.25	NA

FHWA's Right-of-Way (ROW) Research Program enhances State and local government highway agency capabilities in right-of-way program management, technical development and

information sharing. This research effort includes studies that identify and advance right-of-way management methodology; right-of-way technical innovation; and harmonious land use applications.

New research efforts in FY 1997 will include video imaging to enhance understanding and presentations of highway impacts for property owners and in condemnation cases, and additional assessments of right-of way impacts of Federal programs and policies.

FY 1998 milestones include:

- Dissemination of possible "benchmarks" to improve the quality of ROW program management.
- Deployment of interactive video imaging tools for key right-of-way related functions.

Technology Assessment and Deployment (FHWA)

FY	1997	1998	1999
Funding	13,811	14,800	NA
FTE	27	27	NA

The purpose of FHWA's Technology Assessment and Deployment program is to identify and assess innovative research results, technology, and products and to promote the application of those that are determined to be of potential benefit to the highway community. Key areas of interest currently include:

- Roadway Applications - Development of innovative solutions to keep pace with asphalt and concrete pavement rehabilitation.
- Structures and Soils - Application to structural components (e.g., bridges, retaining walls, tunnels, structural signposts) of innovative technology, including high-performance structural materials, modern rational design codes, nondestructive evaluation systems, seismic retrofit techniques, ground improvement methods, and scour protection systems.
- Safety and Design - Safety outreach, hardware, and programs; and motor carrier safety. Examples include a red light running campaign, countermeasures for older road users, and automated brake testing technology for commercial vehicles.
- Traffic and Motor Carrier - Implementation of new and emerging technology in traffic management, simulation, and demand management, and to facilitate the safe and efficient movement of goods by the motor carrier industry.

- **Technology Marketing** - Technology transfer through workshops and demonstrations on breakthrough technologies, international technology scanning, cooperative research, and participation in international organizations.
- **Technology Operations** - Use of advanced media (e.g., Internet, online systems, intranet, CD-ROM, CD-Interactive, multimedia, etc.) to improve the ability to reach users throughout the highway community.

FY 1998 milestones will include:

- Initiation of a demonstration project to assist highway officials in using life-cycle cost analysis (LCCA). This activity will outline the process, identify key data and assumptions, and provide hands-on training on how to perform LCCA.
- Completion of the development, beta testing, and implementation of a comprehensive computer program for designing bridges for extreme events such as ship impacts and earthquakes.
- Incorporation of the Commercial Vehicle Information Systems pilot technology into the Advanced Law Enforcement Response Technology vehicle.
- Demonstration and promotion of leading-edge corridor management technology for freeway and urban arterial traffic control.
- A videotape and multimedia course which shares techniques for the cost-effective use of heat straightening for the repair of damaged bridges.

Local Technical Assistance Program (FHWA)^a

FY	1997	1998	1999
Funding	8,827	12,000	NA
FTE	2	2	NA

The FHWA's Local Technical Assistance Program (LTAP) improves access to highway technology for local communities. The LTAP, with its 57 LTAP technology transfer centers—one in each state, one in Puerto Rico, and six to serve American Indian tribal governments—serves as the primary channel through which innovative transportation technology and training are delivered to both urban and rural communities. Training is provided in a number of ways: workshops at various locations throughout a State; circuit-rider

^aA portion of the funding for the LTAP is through Section 6004 of ISTEA.

visits to local transportation agencies for on-site tutorials or hands-on training; field demonstrations; and lending of training materials (e.g., videotapes, manuals, workbooks).

Key FY 1998 products and milestones include:

- A traffic safety assessment course and field guide for local officials.
- A videotape and pocket field guide on fundamental field testing procedures necessary for basic maintenance and design of gravel roads.
- CD-ROM publication of all LTAP reference information, newsletters, and special reports.

*Technical Training (FHWA)
National Highway Institute*

FY	1997	1998	1999
Funding	4,269	8,000	NA
FTE	13	13	NA

The National Highway Institute (NHI) has a legislative mandate to provide education and training to Federal, State and local transportation agencies in a proactive effort to apply state-of the art transportation technologies emanating from FHWA R&D programs. As such, it is the leading resource within FHWA for providing high quality comprehensive education and training programs tailored to meet the needs of transportation professionals at all levels of the Federal, State and local government as well as U.S. industry. In addition, the NHI is structured to share this information with the international transportation community. The NHI envisions the utilization of both traditional and modern instructional techniques to provide high quality education and training in transportation technology that customers will find to be affordable, convenient and timely.

Domestically, the customer base of the NHI is changing, and the number of students is expected to grow by 25 percent in FY 1998. State DOTs are downsizing, and much of their construction, maintenance and operations are being shifted to contractors who are already beginning to seek NHI training. The remaining State DOT engineers now have to be knowledgeable in a range of subjects so they need a wider variety of NHI courses each year. The number of NHI customers from industry has grown from five percent to 11 percent in four years and is expected to climb to 15 percent in FY 1998.

Internationally, the NHI offers specialized courses to foreign professionals in areas such as technology transfer techniques, advanced pavements technology, and international bridge inspection. The NHI markets its courses in some 30 countries and teaches a few international courses in the United States so that foreign professionals can link up with members of the U.S. transportation industry.

The NHI is meeting these challenges by improving its procurement procedures and modernizing its instructional techniques. In addition to conventional classroom training, NHI deploys or plans to deploy a variety of instructional technologies such as CD-ROM, electronic performance support systems, interactive computer, and virtual reality simulations; and a host of course delivery techniques such as just-in-time training, networked delivery of instruction, satellite broadcast, teleconferencing, and audio and video. These technologies and techniques are optimally adapted to the audience.

The NHI is active in several other areas related to education and training. The NHI operates a College Curriculum Program that makes its training manuals and materials available to university professors for use in updating their courses. The NHI conducts conferences, congresses, distinguished lecture series, seminars, symposia, and workshops; exhibits its services at World Trade Fairs; provides technical assistance to its international customers; administers an international personnel exchange program for FHWA offices; receives over 100 international visitors per year; manages the AASHTO/FHWA personnel exchange program; provides oversight to the FHWA university transportation centers and institutes programs; and grants fellowships to students and faculty members who are pursuing or plan to pursue careers in transportation.

Current activities include:

- Delivering over 500 course presentations on over 120 transportation topics to more than 16,000 participants.
- Conduct presentations that promote intermodal transportation, stimulate understanding of the cross-cutting issues, and foster seamless interaction among the various transportation modes.
- Providing a program of at least 12 courses addressing pavements and materials issues, including Superpave, to train State and local transportation agency staffs. Pavements and materials represent the largest share of capital investment by public agencies.
- Delivering a series of courses on structural foundations. These courses will aid transportation officials in averting bridge failures from natural disasters such as floods or earthquakes.
- Introducing a formal program of NHI courses for the private sector, including transportation companies, contractors, consultants, firms, and materials suppliers. This program is expected to become self-supporting in three years.

Key milestones for fiscal year 1998 will include:

- Delivering over 600 course presentations on over 125 transportation topics to more than 20,000 participants.

- Augmenting classroom training for the 4,000 additional students who will be taking NHI courses in FY 1998 with Distance Learning, "Just in Time" Training, and Interactive Computer Training.
- Develop three more computer-based training courses, similar to the one last year on transportation safety, that will utilize the modern technique of "Just-in-Time" training to provide instruction to workers on the job.
- Develop and present a new course on seismic retrofitting of transportation bridges. The course will be based on technology identified in FHWA research.

Implementation of the Strategic Highway Research Program (FHWA)

FY	1997	1998	1999
Funding	20,000	0	NA
FTE	16	NA	NA

A six-year program of product implementation and continuation of the Long-Term Pavement Performance program related to the Strategic Highway Research Program (SHRP) was authorized under ISTEA. The benefits of the SHRP are being realized through its systematic implementation. Products of the research program are being developed under the guidance of technical working groups, which include FHWA field organizations, industry associations, the Transportation Research Board, and users. Their work includes the following:

- Prepare and conduct showcase packages of technology modules for demonstration and delivery to the states via FHWA regional offices and through workshops for state planners and industry.
- Operate a Technology Delivery Team to address Superpave with representation from the research and development, technology applications, and program offices within FHWA.

Key products and milestones for FY 1998 include:

- Continue implementation of SHRP products for local governments.
- Complete development and field trial of improved prototype Performance Related Specifications for concrete pavement.
- Initiate studies to evaluate the Superpave mixture tests and performance models for rutting, fatigue cracking, and low temperature cracking.

- LTPP verification sections designed and constructed and field assistance provided for Superpave technology.
- Continue demonstrations of the latest test procedures and equipment using the concrete mobile laboratory.
- Design, construct, and evaluate projects using criteria established for high performance concrete pavements.
- Develop interim specifications for Performance Related Specifications for Portland cement concrete and hot-mix asphalt pavements and begin validation of performance models established for use in PRS for concrete paving.
- Complete interim development and assessment of the SHRP binder direction tension test.
- Demonstrate high performance concrete procedures, materials, and equipment to improve the durability and performance of concrete; this will follow up on SHRP concrete durability findings and address additional performance, environmental, and quality issues.
- Accelerate development of performance related specifications for asphalt and concrete pavements. Findings from the WesTrack full-scale accelerated loading test track of the effects of construction and materials variability on asphalt pavement performance will be analyzed to develop pay factor adjustments and to identify construction and materials quality control parameters.
- Work with the State DOTs to adopt the Superpave binder specification by 1997 and adopt the volumetric mix design specifications by 2000 through five Superpave Regional Centers, a pooled-fund equipment purchase for States, a full program of training through the National Asphalt Training Center, and technical assistance.
- Refine concrete and structures technologies and through such means as showcase workshops, introducing them to State DOTs and contractors.
- Ensure that all applicable SHRP products are now provisional AASHTO standards for use by the States and industry.
- Provide information on the products and the schedule for implementation activities through FHWA's SHRP Information Clearinghouse.
- Continue to work internationally to promote cooperation in the use of SHRP technology, including cooperative efforts with Canada, Latin and South America, the European Community, and Japan.

*Technology Implementation Partnership Program
(FHWA)*

FY	1997	1998	1999
Funding	0	11,000	NA
FTE	0	NA	NA

The great value of close partnerships between Department modal administrations and State, local, private, academic, and other entities was proven by ISTEA's implementation of the Strategic Highway Research Program (SHRP) products. It is essential that the Department continue its strong partnership role with State DOTs, the Transportation Research Board, and industry to move technology and innovation into common practice. The Technology Implementation Partnership Program would foster such alliances that support efforts in high-payoff areas.

The Technology Implementation Partnership Program's predecessor, SHRP, received \$108 million as part of the ISTEA legislation. SHRP successfully promoted transportation-community partnerships, with most of the program's implementation efforts directed toward sharing technology with the States and industry, supporting the test and evaluation of products, and associated training and communications activities. This approach has been very successful in terms of the number of individuals who have been introduced to the technology, the extensive product trials, and adoption of the products by the States and industry. The "SHRP Lead States Program," which has recently been initiated by the AASHTO SHRP Implementation Task Force, is an excellent example of the effectiveness of partnerships among Department modal administrations, the State DOTs, and industry.

Expected FY 1998 products and milestones include further development and implementation support in high-payoff areas, such as the Superpave system. FHWA is working with States, academia, and industry to establish a complete program that is well validated, implements performance prediction algorithms, and is universally adopted. The Technology Partnerships Program, too, would support other key alliances.

- Initiation of regional technology excellence centers.
- Initiation of user-producer groups.
- Increased LTPP product implementation.
- Increased technology access/exchange programs.
- Improve information-dissemination networks to reach beyond States to cities, counties, and other localities.

Long-Term Pavement Performance (FHWA)

FY	1997	1998	1999
Funding	6,000	15,000	NA
FTE	0	NA	NA

The Long-Term Pavement Performance (LTPP) program is a 20-year project initiated under the Strategic Highway Research Program (SHRP). The goal of the LTPP program is to extend the life of highway pavements through achievement of the following:

- Evaluate existing design methods.
- Develop improved pavement design methodologies and strategies for the rehabilitation of existing pavements.
- Develop improved design equations for new and reconstructed pavements.
- Determine the effects of loading, environment, materials properties and variability, construction quality, and maintenance levels on pavement distress performance.
- Determine the effects of loading, environment, material properties and variability,
- Establish a national long-term pavement data base to support SHRP objectives and future needs.

LTPP is the largest pavement performance research project ever undertaken. It involves periodic data collection and condition monitoring of approximately 2,200 in service pavement test sections, located throughout the United States and Canada, over a 20-year period. The LTPP research includes two sets of experiments: the General Pavement Studies (GPS) and the Specific Pavement Studies (SPS). The GPS experiments focus on existing pavements and the designs most commonly used in the United States and Canada. Individual test sections offer a wide range of values for key study variables and selected covariates. The SPS experiments involve test sections constructed specifically for the LTPP research and focus on the efficacy of specific pavement design factors involved in new pavement construction, the application of maintenance treatments to existing pavements, and pavement rehabilitation.

Major activities and accomplishments for FY 1997 include:

- Handbook(s) for the design and construction of long-lived Portland Cement Concrete (PCC) pavements were developed including: (1) guidelines for the selection of k values on the basis of soil type and site conditions or backcalculation; (2) validation of the NCHRP 1-30 performance model for rigid pavements; (3) quantitative estimates of the effects of key design features and practices on PCC

pavement performance; and (4) improved performance prediction models for PCC pavements.

- A validated temperature prediction procedure for asphaltic concrete (AC) pavements; temperature adjustment procedures for backcalculated moduli, deflections, and basin characteristics; draft standard for temperature prediction and correction in the structural evaluation of AC pavements was developed.
- A new hot-mix asphalt (HMA) pavement design handbook providing guidance on: (1) use of backcalculated and laboratory moduli in pavement design; (2) estimation of moduli from other materials data; (3) consideration of drainage conditions in pavement design; (4) characterization of the subgrade, including seasonal variations; and (5) estimation of AASHTO layer coefficients in light of seasonal variations in layer moduli was published.

Expected FY 1998 milestones include:

- "Master Analysis" of all LTPP data to develop improved pavement design methodologies and strategies for the rehabilitation of existing pavements for new and reconstructed pavements and to determine the effects of loading, environment, material properties and variability, and construction quality on pavement distress and performance.
- Completion of all laboratory materials testing of SPS and GPS test samples.
- Completion of construction of all SPS projects.

Advanced Research (FHWA)

FY	1997	1998	1999
Funding	0	10,000	NA
FTE	0	NA	NA

The advanced research concept exists in response to the observed need to have research and development units dedicated to the investigation of new, emerging or advance technologies which have potential, for long range application in highway engineering R&D and in safety and traffic operations R&D. This is to ensure that there is a central focus and continual surveillance of emerging and advanced technologies. The main activity areas for the advanced research program reflect the current and future needs of research and development and are:

- Diagnostic methods
- Materials characterization

- Modeling and simulation technologies
- Artificial intelligence and mathematics
- Advanced sensor and communications technologies

Expected FY 1998 products and milestones include:

- Preliminary guidelines for diagnosis of ettringite-related distress.
- Full scale installation of Bragg grating fiber optics monitoring system on one or more highway bridges.
- Completion of digital waveform-based acoustic emissions measurement
- Field evaluation of portable neutron/gamma spectroscopy system for detection of chlorides in Portland cement concrete.
- Completion of testing of the effect of fatigue on the fundamental properties of aging steel.
- Preliminary model identified for drowsy driver warning system.
- Initiation of at least one formal study applying multi-criteria optimization methods. Two possible topics are optimum intersection light timing or optimum safety project selection over a network.
- A breadboard tool will be completed combining object oriented approaches with graphical user interface to allow rapid prototyping and analysis with visual presentations. This tool (the Equation Shell) will be of use to researchers for analysis of data, the incorporation of research findings in the development of new products, and as a technology transfer mechanism.
- Vehicle magnetic signature database: This database will update vehicle magnetic signatures which were last measured during the early 1970's.
- Smart loop detector field test and evaluation: This effort will determine smart loop detector performance specifications and develop functional specifications for detector communications to the traffic controller.

*Applied Research and Technology Program
(FHWA)*

FY	1997	1998	1999
Funding	41,000	0	NA
FTE ⁹	NA	NA	NA

ISTEA Section 6005 laid out the Applied Research and Technology (ART) Program with the goal to accelerate the testing, evaluation, and implementation of technologies to improve the durability, efficiency, environmental impact, productivity, and safety of highway, transit, and intermodal transportation systems. The legislation had several requirements and special provisions:

- It required the development of Guidelines for the selection of technologies to be tested.
- It broadly described the types of technologies to be tested.
- It designated specific technologies that were to be tested.
- It required the projects to be carried out on the "Federal-aid systems" with the Federal share not exceeding 80 percent.
- It provided for technical assistance to the States and for an annual report to Congress.
- It provided funding of \$35.0 million for fiscal year 1992 and \$41.0 million for each of the fiscal years 1993-1997 for the overall program and provided funding of not less than \$4.0 million per fiscal year for heated bridge technologies, not less than \$2.5 million per fiscal year for thin bonded overlays, and not less than \$2.0 million per fiscal year for all weather markings.

To implement the provisions of the legislation, FHWA, through the Research and Technology Executive Board, developed a program composed of three elements: Priority Technologies, Test and Evaluation through the Highway Innovative Technology Evaluation Center (HITEC), and Applied Research. The programs are jointly administered by the Associate Administrators for Safety and System Applications and Research and Development with funds assigned to a variety of headquarters offices carrying out the program.

Priority Technologies involve the implementation and evaluation of technologies specified in the legislation and other priority technologies that have been identified by FHWA and proposed for partnerships through general solicitation. Test and Evaluation Through HITEC involves full-scale testing of new technologies of projects originating in both the public and private sector coming through HITEC. The use of HITEC was incorporated into the

⁹The FTE to administer this program are located in various research and technology offices throughout FHWA.

Guidelines that FHWA developed. Applied Research projects support the development of R&D products, the implementation of new technologies and support for International activities and the Advanced Research Program.

Key products and milestones for FY 1998 will include:

- Continue the Priority Technology Program through which projects identified by FHWA fields offices to accelerate the testing, evaluation, and implementation of new and underutilized technologies that will benefit the intermodal transportation system by improving the durability, efficiency, environmental impact, productivity, and safety. The program operates through cost-sharing partnerships between the public and private sectors.
- Complete or continue evaluations of thin bonded overlay projects at sites around the country.
- Complete or continue evaluations of heated bridge deck projects at sites around the country.

*National Technology Deployment Initiatives
(FHWA)*

FY	1997	1998	1999
Funding	0	56,000	NA
FTE ¹⁰	0	NA	NA

The National Technology Deployment Initiatives (NTDI) will build upon the success of the Applied Research and Technology Program (ISTEA Section 6005), which focused on the application of new and innovative technologies. The NTDI will focus on accelerating the implementation of technologies that will address a set of specific "customer driven" technology goals, such as improving safety of nighttime driving, driving in wet weather, and other periods of limited visibility; reducing the delays and accidents resulting from construction and maintenance work; improving quality and durability of construction materials; extending the life of the current infrastructure; and incorporating technologies in all phases of construction and operations that support and enhance the environment. This program will have two major components to support the achievement of these goals: authorized funding and program incentives.

The National Technology Deployment Initiatives (NTDI) program is designed to greatly expand the application of innovative technologies to directly benefit transportation system users through reduced delays, extended life of the transportation infrastructure, improved system reliability, improved safety, enhanced environmental features, and support for sustainable

¹⁰The FTE to administer this program are located in various research and technology offices throughout FHWA.

growth. These goal areas directly respond to input received by the Department as part of reauthorization outreach efforts, in addition to priority concerns of customers, as identified by the 1996 National Highway User Survey commissioned by the National Quality Initiative (NQI) Steering Committee.

This proposed program would be designed to deliver resources to a focused set of program areas that will result in significant, tangible benefits to transportation users. A major theme is to foster actual deployment of projects so that users will quickly benefit from applications of innovative technologies, leading to greater acceptance and willingness by States and others to use alternative funding sources for such projects.

Proposed goal areas directly address areas that are very high priorities of our customers, as indicated by the recent survey conducted for the NQI Steering Committee. Characteristics of the program follow:

Customer-Driven—The program objectives, delivery mechanisms, and schedule would target innovative technologies that have tremendous potential to result in direct, tangible benefits to customers. The involvement of public and private area stakeholders will be important to the program design and widespread dissemination of lessons learned, quantifiable results, and products developed.

Deployment-Focused—This program would also be designed to "get projects on the ground" in order to show results from application of the technologies and deliver expected user benefits. Emphasis will be on supporting States and other implementers with funding and technical assistance in the deployment of innovative technologies. Where needed to directly support the deployment goals, program funding will also support highly focused research, test, evaluation, training, and demonstration efforts.

Innovative Delivery Mechanisms—The program would use both innovative and traditional mechanisms. Potential features include authorized funding for participation by States and other implementation agencies, program incentives, regulatory flexibility, and cooperative projects. Resource and risk pooling in concert with key public and private technology partners is also envisioned.

Multimodal Support—The technology goal areas address universal themes such as extended infrastructure life, use of better performing materials, transportation network efficiency, and environmental enhancement. Applications of these technologies will benefit roadway, transit, and railway systems.

Through this program, the Department, along with key technology partners, would potentially address six specific goal areas:

- Reduce delay and improve safety within construction and maintenance work areas.
- Extend the life of the current infrastructure.
- Increase system durability and life with high performance materials.
- Support and enhance the environment with use of innovative technologies.
- Increase use of alternative modes to improve community-level transportation service.
- Minimize snow and ice impacts to the transportation system.

The NTDI program must remain responsive to the very dynamic nature of technological development and progress within transportation agencies. These advances may originate within the transportation community, or from other areas such as materials science, human factors, and structural design/construction engineering. In addition, the priorities of users and capabilities of delivery organizations do change over time. For these reasons, the Department would be encouraged to develop and maintain close working relationships with other public and private sector entities, and be authorized to add new goal areas and refine existing areas as needed.

The NTDI program would be managed by the Department as a major element of the overall Research and Technology Program. All of the R&T program elements are designed to be complementary, with the NTDI program providing the key resource to help "close the gap" between current construction, maintenance, and operation practices, and greatly expanded adoption of innovative technologies. It is expected that the FHWA will be the lead agency for this program, in cooperation with other Department modal administrations, including the Federal Transit Administration, the Federal Railroad Administration, the National Highway Traffic Safety Administration, and the Research and Special Programs Administration. Key program operation/management features would include:

Program Evaluation/Assessment of Opportunities—To the extent possible, program goals will be quantifiable, and continuing evaluation will be used to define need for redirection. New technologies that may support the goals should be identified, evaluated, and applied expeditiously.

Partners/Stakeholders—Regular interaction with key stakeholders regarding program delivery mechanisms, refinement of goal statements, cooperative efforts, and other matters is essential. These stakeholders include public sector entities such as State DOTs, local

governments, and local transit authorities; private sector companies; industry associations; and academia.

Information Sharing—The overall goal of increasing adoption of innovative technology requires that decisionmakers at the State and local levels have quick and efficient access to reliable, up-to-date information. This is expected to be an important focus of the NTDI program's management system.

Technology adoption by public agencies and private companies entails a fair degree of risk. Public agencies, in particular, have been reluctant to adopt innovations that have not been proven to be effective or that do not appear to have continuing, long-term support. Reliable, consistent funding would be a necessary feature of the NTDI program.

Seismic Research Program (FHWA)

FY	1997	1998	1999
Funding	2,000	0	NA
FTE	2	0	NA

This FHWA research program for the seismic protection of bridges studies the seismic vulnerability of highways, and bridges on the Federal-aid system and works to develop and implement cost-effective methods of retrofitting such systems to improve their seismic performance. Remaining efforts in FY 1997 include:

- Complete evaluation of approaches for portraying the National hazard exposure to the highway system.
- Complete development of design time history ground motion.
- Complete seismic retrofit of shear-critical bridge columns with final report.
- Complete development of training course for seismic retrofitting for bridges.
- Complete study of "Effect of Spatial Variation of Ground Motion on Highway Structures."
- Complete Liquefaction Remediation Techniques for Bridge Foundations.

Timber Bridge Research Program (FHWA)

FY	1997	1998	1999
Funding	1,000	0	NA
FTE	1	0	NA

FHWA's Timber Bridge Research Program focuses on developing new timber bridge systems, and/or improving present systems which permit the efficient use of primary commercial wood species and previously under utilized species for transportation use. Remaining activities in FY 1997 include:

- Standard plans for several timber bridge types.
- Computer design aids, and interactive designs.
- New NCHRP 350, Test Level 3 bridge rails.
- Refined design criteria to update AASHTO codes.
- Find alternative stressing systems for post-tensioning stressed deck bridges.

Research & Technology Technical Support (FHWA)

FY	1997	1998	1999
Funding	0	10,000	NA
FTE ¹¹	0	NA	NA

Responsibility for transportation research in the U.S. is highly decentralized. States, universities, private entities, as well as the Department of Transportation all play important roles in defining the research agenda, and in conducting the actual research. FHWA research and technology technical support ranges from sponsorship of the Transportation Research Board (TRB) and AASHTO; to funding for the Small Business Innovation Research (SBIR) program; to data processing and editorial support for the Turner-Fairbank Highway Research Center (TFHRC); to quarterly publication of *Public Roads*, which features developments in FHWA's policies, programs, and research and technology.

¹¹The FTE to administer these activities are located at various offices within FHWA.

Track, Structures, and Train Control (FRA)

FY	1997	1998	1999
Funding	7,346	7,746	NA
FTE	3	NA	NA

The goal of FRA's Track, Structures and Train Control research program is to improve the safety and reliability of the Nation's railroad tracks by participating with industry in efforts to address track geometry and material, signal defects, and other train control systems. Track defects are one of the leading cause of train accidents, and the damage associated with those accidents totals on the order of \$50 million annually. The program will work to develop technology to discover such track defects before failure; develop methodologies for predicting service life of track and signal components and how they behave under dynamic conditions; develop protocols to improve efficiency in inspection, preventive maintenance, repair, and renewal actions; and develop technology to enable safe train operation in a heavy tonnage environment. Research will increase emphasis on the testing, analysis, and evaluation of safety-critical track, grade crossing, signal system components, inspection devices, and vehicle response to track irregularities. Current research efforts include:

- Track and Components - Quantifying the resistance of concrete-tie tracks to lateral buckling from heat and load stress; measuring track impacts of heavy vehicles with improved suspensions; assessing performance of improved steel material for select track components.
- Inspection and Detection - Improving and automating track geometry measurement for derailment risk assessment; assessing the feasibility of rail flaw detection through horizontal shear electromagnetic acoustic induction.
- Track/Train Interaction - Developing algorithms for the real-time assessment of the safe limits of track geometry; identifying the correlation between track geometry/stiffness and wheel/rail forces; developing computer models for simulating the dynamic interaction between vehicle and track.
- Signals, Train Control, Communications, and Electrification - Assessing the reliability of new technologies embedded into existing signal systems; improving methods for detecting train presence on track and grade crossing approaches; developing means for assuring safety of electrified railroad operations in new corridors.

Key milestones for FY 1998 will include:

- Improved track inspection protocols based on an improved understanding of crack growth rate for newly-discovered rail flaw type initiated by stress and heavy wear deformation.

- Novel methods or standards for rating the safety of track condition using newly-integrated track and vehicle models.
- Improved means for integrating train presence sensors and train control systems.
- Assessment of the safety impacts of data transmission “backbones” for sensor and control elements of intelligent train systems.

Next Generation High-Speed Rail Facilities Improvements (FRA)

As part the Next Generation High-Speed Rail Program, discussed below in Chapter 4, FRA will be providing funding to the State of Oregon to upgrade tracks, control systems, and terminals on the Portland-Eugene Corridor. Included in the project will be an examination of new techniques for the construction and maintenance of track for high-speed passenger operations.

Intermodal Development (MARAD)

FY	1997	1998	1999
Funding	0	0	NA
FTE	NA	NA	NA

The goals of the Maritime Administration's Intermodal Development program are to assess and deploy innovative technology and management practices for all components of the transportation system infrastructure to improve system capability, efficiency, productivity, safety, environmental sensitivity, and military utility. In addition to SBIR agreements discussed in Chapter 7, there are four research programs under Intermodal Development:

1. Intermodal Transportation Research Program -- This program works to improve the efficiency of all aspects of the flow of cargo and data from origin to destination in U.S. domestic and international trade through the introduction of advanced technologies and operating systems designed to enhance productivity, reduce costs, and increase service quality. MARAD assists U.S. ocean carriers, inland waterway operators, stevedores, terminal operators, ports, and others involved in intermodal transportation through National multi-modal studies and joint MARAD/industry cost-shared research and development. MARAD provides for coordination of intermodal studies with the Department's Office of Intermodalism and other modal administrations, as well as other Federal, state, and local agencies.

2. Cargo Handling Cooperative Research Program -- This cost-shared program is carried out under a cooperative agreement between MARAD and industry members to improve the cargo handling productivity of American carriers. The research activities are jointly selected by the participants.

3. Commercial-Military Transportation Research Program -- This program focuses on the identification and development of marine intermodal transportation technology which can be used to meet military and commercial requirements.

4. Port Development Planning Research Program -- The Maritime Administration's Port Development Research Program goal is to determine port requirements for U.S. ports in order to improve transportation system capability, efficiency, productivity, and safety. The program also ensures that ports are able to operate with efficiency and minimal disruption during times of National emergency. Related near-term activities include:

- Complete the study and workshop on the impact of future fleet and trading pattern changes on port infrastructure requirements.
- Completion of the National Freight Transportation and Logistics Model, which will provide planners with the ability to identify potential infrastructure constraints and allow for the testing of options to address the constraints.
- Initiate development of a port productivity program designed to assist U.S. ports in enhancing their marine terminal productivity and facility utilization.
- Develop analytical methodology for assessing the security vulnerabilities of marine terminals.
- Examine the special problems and future role of small and modern-sized U.S. ports.
- Examine the issues associated with competition between U.S. ports and regional economic efficiency and cooperation in planning.

New Rail Vehicles & Infrastructure (FTA)

FY	1997	1998	1999
Funding	200	800	NA
FTE	NA	NA	NA

Transit agencies operating rail above grade and in subways find it difficult to provide greater capacity, and agencies developing new starts are continuing to experience cost overruns. Studies have shown that communication-based train control systems provide greater throughput at far less cost than infrastructure expansion. Other future benefits of this technology are grade crossing protection, real-time customer information, and commercial adaptation by freight railroad companies (which should lower cost to transit operators). Projects

participating in the FTA Turnkey Demonstration Program are already starting to demonstrate the cost control and financing benefits of the turnkey method of infrastructure project delivery.

FY 1998 activities will include offering technical support in completing development and deployment of the advanced technology train control system, exploring other uses of communication-based technologies including improving commuter rail safety, initiating the update of the subway environmental design handbook based on testing completed at the Memorial Tunnel test site in West Virginia, providing further support to the Turnkey Demonstration Program, and assisting with implementation of the FTA Innovative Finance Initiative.

Pipeline Safety Research (RSPA)

FY	1997	1998	1999
Funding	1,644	1,648	NA
FTE	NA	NA	NA

RSPA's Pipeline Safety Research program provides technical competence to assess pipeline integrity, determine ways to rehabilitate or rebuild pipelines, and set long-term performance goals for improvements. Current research activities include:

- Information Systems - Facilitating risk-based planning through the integration of operator compliance systems with incident and other operational data bases; improving wide area network links to resource availability, operator safety measures and recommendations for regulatory development; and testing applications of a national pipeline mapping system.
- Research Studies - Completing evaluation of leak detection system performance; evaluating pipeline design and operating criteria, including leak before rupture, fracture mechanics, and pressure limitations; and modifying existing nondestructive diagnostic technology used to detect wall thinning to detect external dents and flaws caused by external forces.
- Compliance - Completing an assessment of the degree to which tanks meet American Petroleum Institute (API) standards.
- Management and Analysis - Redesigning risk prioritization processes to focus on field practices.

Major FY 1998 products and milestones will include:

- An evaluation of the first year of expert information systems operations and strategic plan for improving analytical capabilities.

- **A study of steel strength and toughness limitations.**
- **A study of plastic and composite distribution gas piping technology.**
- **Testing of the second generation risk prioritization model.**



CHAPTER 3

INFORMATION INFRASTRUCTURE

Introduction

The importance of timely, accurate and complete information to effective transportation planning and operations has become undeniable in recent years. New communications and information systems technologies are developing rapidly, and there are unprecedented opportunities for making substantial improvements to transportation through their effective implementation.

In order to capitalize on the potential advantages of these new technologies, the Department of Transportation has established as a strategic goal to *"Create a new alliance between the Nation's transportation and technology industries to make them both more efficient and internationally competitive."* [Strategic Goal #3 in the Department's *Strategic Plan*]. This goal envisions a future intermodal transportation network in which each mode uses information systems and technologies to operate more effectively, both by themselves and as an integral part of the larger, seamless transportation system for moving people and goods safely and efficiently throughout the United States and to and from foreign destinations.

This vision for the future of transportation has striking similarities with depictions of the evolution of the National Information Infrastructure, or the NII. In fact, the direct parallel between effective transportation and effective communications services has been pointed out by noting the NII can "have the same effect on U.S. economic and social development as public investment in the railroads had in the 19th century." [Federal Interagency Information Infrastructure Task Force, The National Information Infrastructure Agenda for Action, September 1993]. There has already been discussion of the advantages of defining a 'Transportation Information Infrastructure' or 'TII', to encompass those components of the NII whose primary purpose is to expedite the flow of passengers and freight on the National transportation system. If this concept were adopted, then the Federal government and the Department of Transportation would have significant and important new responsibilities.

However, a coordinated and comprehensive Federal approach to managing this intersection of transportation and communications has yet to be formulated. This would be a complex endeavor that would need to address a number of topics, such as:

- the need to support large numbers of both mobile and fixed users and platforms;
- the need to transmit significant amounts of data in real-time or near real-time;

- the need for seamless inter-connectivity among communications modes (wired, wireless, hybrid) and regions, both nationally and internationally, including managing the allocation and use of communications spectrum;
- the need for high reliability and survivability for safety-critical and National security-related applications; and
- the need to ensure compatibility among the regulations, legislation and administrative procedures of numerous public authorities at the local, regional, state, National and international levels.

Even given these daunting parameters, it is in fact possible to integrate state-of-the-art communications and information systems technologies into transportation. In many ways, the Intelligent Transportation System (ITS) program, previously known as Intelligent Vehicle Highway Systems (IVHS), is a model for the advantages that can accrue when the latest information and communications technologies are applied to transportation.

Intelligent Transportation Systems (ITS)

The ITS program arose in the late 1980s out of an awareness that parallel advances in such fields as electronics, communications, control, and information processing technologies offered a unique opportunity to make profound improvements in the Nation's surface transportation system. The ITS program seeks to apply these technologies in a manner that will enable the public to use the Nation's surface transportation infrastructure and energy resources to help achieve multiple goals simultaneously, including: improved safety, increased efficiency of transportation operations, reduced environmental and energy impacts of transportation activities, enhanced economic productivity, and enhanced mobility for transportation users.

The Federal Government is only one, although a major, participant in the National ITS program. Other players include private electronics, communications, and transportation technology companies; professional societies and organizations; consumer and industry groups; academia; and State and local governments. In addition, the Intelligent Transportation Society of America, or ITS America, is utilized as a Federal Advisory Committee to advise the DOT on the ITS program.

The primary role of the Federal Government, and of DOT in particular, in this program is to assure the development and deployment of a truly compatible, nationwide ITS system. This is accomplished through a number of coordinated activities. DOT encourages and coordinates the development of uniform technologies, standards, and associated knowledge bases. Because of its statutory mandate, the Department also provides a National emphasis and perspective on the safety aspects of ITS. It funds high-risk research that has the potential for a significant

public benefit, but is not sufficiently attractive for the private sector to pursue. It also plays a major role in ITS operational tests, technology assessment, and program planning.

Within DOT, the Joint ITS Program Office, or JPO, is housed in the FHWA and reports to the ITS Management Council chaired by the Deputy Secretary, and consisting of the administrators of FHWA, NHTSA, FTA, FRA, and FAA, as well as to the General Counsel, the Assistant Secretary for Transportation Policy, and the Assistant Secretary for Budget and Policy. The JPO coordinates the Department's overall ITS activities within FHWA itself, NHTSA, FTA, FRA, RSPA, and OST. Other Federal organizations with significant roles in the ITS program include the Departments of Treasury, Commerce, Justice, and Energy; the Federal Communications Commission, the Environmental Protection Agency, and the National Laboratories.

The Department's ITS program has already achieved a number of significant accomplishments. It has cooperated with ITS America to produce a *National ITS Program Plan* in March 1995, and has developed a coordinated set of "road maps" that mark milestones and critical paths for achieving program objectives. It has stewarded 77 operational tests that have demonstrated the viability of "first generation" ITS technologies and services. It has launched an aggressive short- and long-term research program that has moved technologies largely unfamiliar in transportation five years ago into actual use. It has identified institutional barriers to ITS implementation, and proposed solutions to remove those barriers and mainstream ITS deployment. It has developed a national architecture that can facilitate the integration and interoperability of ITS user services. It has identified and promoted technical standards that assure hardware and software compatibility. It has created new models of private/public partnerships. It has developed plans to meet educational and human resource needs. Finally, as is discussed below, it has set national goals to encourage widespread ITS deployment.

The Federal Deployment Strategy for ITS

In addition to conducting an ITS research, development, and testing program, Congress directed the Secretary of Transportation to promote the nationwide deployment of ITS to solve transportation problems. In early 1996, the Department announced national deployment objectives to create:

- Infrastructure for metropolitan areas that would integrate nine first-level ITS advanced travel management services. These services would apply to traffic signal control, freeway management, transit management, incident management, electronic toll collection, fare payment, railroad grade crossings, emergency management, and regional multimodal traveler information centers.

- **Commercial Vehicle Information Systems and Networks (CVISN)** that would form a communications and information backbone to support and integrate ITS services that aid commercial motor carrier operations.

The Department also expects to create an intelligent transportation infrastructure that would enrich and improve transportation services in the Nation's diverse rural communities. The Department formed these deployment objectives gained from the program's extensive research over the past five years, which indicate that smart transportation systems are technically viable, that ITS offers demonstrable benefits, that user acceptance of ITS user services is growing, that institutional barriers pose the greatest challenge to ITS deployment, that deployment is happening in an narrowly focused and disconnected fashion. These findings collectively reinforce the advantages of having a set of 'core infrastructure' elements in place in different regions throughout the Nation. Once installed, these elements would generate for public awareness the real safety, security and congestion benefits of ITS technologies. They would also serve as the foundation for the deployment of more advanced ITS features as they became available. In order to save time, save lives, and improve the quality of life for all Americans, the Department plans to facilitate deployment of intelligent transportation infrastructure in the following areas:

- **Metropolitan** -- Full implementation, including advanced travel management systems and advanced public transportation systems capabilities, in 75 of the largest metropolitan areas in the Nation within 10 years.
- **Commercial Vehicle Operations** -- Deployment of CVISN to achieve safe and efficient shipping operations and enable electronic business transactions by the year 2005 in all states.
- **Rural** -- Upgrade technology in 450 other communities, rural road, and the National Highway System as warranted.

A range of activities are underway in support of these goals. The Model Deployment Initiative has chosen four urban sites that will become models for other metropolitan areas to emulate as they plan the deployment and implementation of an integrated, fully functioning advanced travel management system. The ITS program will also support continuing standards development and professional capacity building activities. The Department has formed partnerships with Maryland and Virginia to prototype the CVISN technologies and demonstrate and refine the operational concepts. In 1997, the Department will launch seven CVISN pilots or model deployments, all of which have now been selected, of electronic data interchange, clearinghouses, Safety and Fitness Electronic Records (SAFER), and state systems compliant with CVISN architecture. The Department is developing a strategic plan to achieve the rural goals for ITS, and plans to facilitate the near-term deployment of an integrated rural travel management system that will provide emergency management services, traveler information, and safety and hazard warnings unique to the requirements of rural drivers.

Future Directions for ITS

As was mentioned previously, the Department's ITS program can already claim a number of successes. As the focus of the program moves from planning and R&D increasingly to the more complex stage of implementation, however, new themes will come to dominate the Department's activities. Over the next several years, the following themes are expected to become prominent, and are reflected in the Department's ITS plans:

- accelerating the installation of advanced travel management systems and CVISN at the state and local level through deployment incentives;
- field testing new technologies such as crash avoidance systems and advanced vehicle control and information systems;
- refining ITS system architecture and developing technical standards; and
- training the "next generation" of transportation planners, engineers, and managers, to provide the professionals needed to design and build future intelligent transportation systems from a systems integration perspective.

In addition to these major themes, a number of issues will need to be discussed and resolved in order to maintain the momentum of the ITS program. For example, there are important questions over the wireless spectrum needs of a fully installed ITS network and guaranteeing that the requisite bandwidth will be available when it is needed. There is also concern from the private sector over the impact of publicly-owned wireline communications systems, especially those based on fiber optic cables, that may support ITS but have considerable excess capacity that could be offered or sold to other users. Finally, responsibility for the effective long-term maintenance of the vast array of software, system architecture and technical standards generated by ITS, and resident in a number of separate public and private sector organizations, must be confirmed. The Department is taking action in each of these areas to begin the process of addressing and resolving these concerns.

NHTSA Collision Avoidance Research

The Collision Avoidance Research program, administered by NHTSA, seeks to facilitate the identification and development of effective safety-related ITS products and systems that will contribute to a safer driving experience for all highway users. In pursuit of this goal, it is envisioned that a wide variety of innovations can be implemented to supplement the driver's ability to maintain vigilance and effective vehicular control. These innovations -- many of which will rely on state-of-the-art communications, information systems and sensor technologies -- would monitor the drivers' own physiological condition, enhance perceptions

of the driving environment, provide additional information about potential safety hazards, warn of impending collisions, assist in making appropriate vehicular maneuvers and even intervene with automatic controls to help avoid such collisions. Thus, the collision avoidance program supports a number of the Department of Transportation's major goals, including: contributing to the National economy, advancing U.S. technology, and supporting the safety of the transportation system.

The collision avoidance program is pursuing a multifaceted research and development effort incorporating five major thrusts:

- Thrust #1** Develop research tools such as portable data acquisition systems that can be installed in vehicles, and utilize these tools to develop a better understanding of driver-vehicle interactions and in estimating safety benefits of potential countermeasures concepts.
- Thrust #2** Conduct detailed analysis of crash databases, develop descriptions of specific crash problems to be addressed (road departure, rear-end, lane change/merge, backing, etc.) and identify potentially promising countermeasures for further research.
- Thrust #3** Develop performance guidelines for countermeasures associated with these crash categories, as the basis for developing crash avoidance systems.
- Thrust #4** Work cooperatively with private industry and research institutions to facilitate the commercial development of promising crash avoidance systems.
- Thrust #5** Assess the safety of ITS mobility- and productivity-enhancing systems to make sure they do not degrade safety.

The NHTSA collision avoidance program addresses the collision problems in three countermeasure areas, focusing on countermeasures for specific collision types, system approaches that enhance driver performance under certain situations, and approaches for mitigating the consequences of collisions. Over the next five years, several activities will receive increased emphasis: rear-end collision avoidance, intersection/railroad collision avoidance, single vehicle road departure collision avoidance, lane change/merge collision avoidance, heavy vehicle stability enhancement, drowsy driver monitoring, driver vision enhancement, and automated collision notification.

The significant near-term products and current and planned activities of the NHTSA crash avoidance program can be found in the program summaries in this chapter ('Research and Development--Crash Avoidance', 'Operational Tests--Collision Avoidance', and 'Crash Avoidance--Driver/Vehicle Performance'), as well as in other chapters of this report ('Crash

Avoidance Research--Heavy Vehicles' in Chapter 4, and 'National Advanced Driving Simulator' in Chapter 6).

Other Information Infrastructure Programs

In addition to ITS and crash avoidance, other surface and non-surface DOT programs also reflect applications of information technologies to transportation. FRA's Next Generation High-Speed Rail program is funding three positive train control projects which utilize datalink communications and GPS positioning. The Maritime Administration (MARAD) manages an Industry Competitiveness program which places a high priority on the identification of information, communications and navigation systems and technologies that can improve the U.S. maritime industry's competitiveness. The Research and Special Programs Administration's (RSPA) Hazardous Materials Research program relies heavily on the application of information and navigation technologies to support its regulatory enforcement responsibilities. The Response Management Support program, also in RSPA, manages crisis management systems that enable the Secretary of Transportation and senior DOT officials to respond effectively to natural disasters or other National emergencies. Other non-surface transportation activities that have an important impact on surface transportation can be found in the Federal Aviation Administration's Aviation Satellite Navigation program, and the U.S. Coast Guard's work in differential GPS.

Finally, there are several related surface transportation R&D programs with a major information technologies content which are described in other sections of this document. The data collection and analysis and system assessment activities undertaken by the National Highway Traffic Safety Administration (NHTSA), the Federal Transit Administration (FTA) and the Bureau of Transportation Statistics (BTS), for example, are described in Chapter 6 of this section.

Near Term Efforts

The remainder of this chapter presents the Department's near-term program plans for information infrastructure research and development. The Department's ITS research and development is funded through the FHWA budget, under the following broad program titles:

- ITS Research and Development
- Advanced Vehicle Control and Information Systems
- Operational Tests
- Evaluation/Program Assessment
- Architecture and Standards
- Mainstreaming

- Program Support
- ISTEA Section 6058 Funds

It is at this level that budget authority for the ITS program is defined, and the budget data presented in this report reflect that authority. Because several of these funding categories encompass a broad range of specific research activities, in some cases managed by different operating administrations within the Department, this chapter describes the specific activities of the ITS research program at an additional level of detail. The allocation of funds for those specific activities is managed and reported separately by the ITS Joint Program Office (JPO), within the discretion afforded to the Department by statute. The Department's other information infrastructure research is presented using the same approach as in the previous chapter.

Research and Development (FHWA)

FY	1997	1998	1999
Funding	28,605	45,500	NA
FTE	NA	NA	NA

Activities included in ITS Research and Development include: Traffic Management and Control, Crash Avoidance Research, Enabling Research, Rural Research, High Risk Research, Other Research, Advanced Transit Management Research, Commercial Vehicle Operations, and Highway/Rail Intersection Innovative Development Research. Each of these programs is described in detail below.

Research and Development--Traffic Management and Control (FHWA/FTA)

Research in traffic management and control will improve efficiency and mobility by developing improved methods for managing traffic, evaluation tools to support the required investment decisions, interface specifications, and technical assistance to the end users of the products. These products will facilitate the adoption and implementation of advanced traffic management and control techniques by state and local transportation agencies.

Current research activities include:

- Development of a Traffic Research Laboratory (TREL) which is a simulator for the testing and integration of ATMS technologies.
- Field testing of real-time traffic adaptive signal control (RT-TRACS) implementing various control algorithms operating in different geographical locations and under differing traffic conditions.

- Completion of functional requirements for sensors and detectors needed to support ATMS and facilitate the industry-driven development of sensors to meet those requirements.
- Investigation of surface street incident detection issues and achievement of acceptance from the user community for definition of what constitutes a surface street incident.
- Development of a functional design to integrate traffic, planning, and other analytical tools and practices for use by Metropolitan Planning Organizations (MPOs) in the development of Transportation Improvement Programs (TIPs).

Key milestones for FY 1998 will likely include:

- Testing of innovative traffic signal control algorithms for use with RT-TRACS that increase its effectiveness, such as those for surface street mass transit systems or those that allow for forecasting of traffic demand on a network-wide basis.
- Development of the overall design for a prototype traffic analysis tool for use by MPOs in the development of TIPs and provide them with the functionality to assess individual intelligent transportation infrastructure components.
- Integrate transit and APTS capabilities in the development of planning models.

Research and Development--Crash Avoidance (NHTSA)

NHTSA's Crash Avoidance research facilitates the development and deployment of effective collision avoidance systems and other motor vehicle systems using intelligent technologies to reduce the number of collisions, prevent injuries, and improve safety in automobile crashes. This research also ensures that safety is not degraded by new ITS products that may be introduced by automobile manufacturers.

Current research activities include:

- Completion in FY 1997 of development of a System for Assessing the Vehicle Motion Environment (SAVME). This new research tool will provide the capability of quantitatively describing the variety of dynamic vehicle interactions experienced during normal driving and how drivers react to these situations. This information will be useful for defining test conditions and analyzing potential benefits of collision avoidance systems.
- Completion in FY 1997 of the development and validation of the Data Acquisition System for Crash Avoidance Research (DASCAR). This new research tool will provide the capability to perform detailed studies of driver behavior during normal driving operations.

This information will be useful for developing performance requirements for collision avoidance systems and for analyzing the potential benefits of collision avoidance systems.

- Evaluation of the impact on safety of the ADVANCE route guidance and navigation operational test.
- Completion of a cooperative agreement with a consortium of motor vehicle manufacturers and suppliers, focused on cost reduction and advances in manufacturing techniques related to collision avoidance systems.

Key milestones for FY 1998 will include:

- Final performance standards for all major first-generation advanced technology collision warning/avoidance systems will be completed.
- Automated Collision Notification (ACN) operational field test and independent evaluation will be completed.
- Refinement efforts for a commercially viable system for Drowsy Driver Detection in heavy vehicles will be completed.

Research and Development--Enabling Research

Enabling research will contribute to the efficiency, mobility, and personal productivity of transportation through research in human factors and communications and navigation technologies.

Current research activities include:

- Completion of human factors empirical research regarding travelers' information needs and preferences for routing, departure times, and rerouting information, as well as research concerning the structure of routing messages, driver routing and rerouting decision sequences.
- Delivery of guidelines and user requirements for augmentation of the Global Positioning System (GPS) for surface transportation users.
- Development of a model of electromagnetic compatibility used to develop guidance on the compatibility of ITS devices in a roadway environment.

Key milestones for FY 1998 will likely include:

- For the In-Vehicle Information System behavioral model and support system effort, the system specification document, the human computer interface specification, and the software specification will be completed.
- Technical support of the ITS petition to the FCC for a spectrum allocation from 5850-5925 MHZ, and uncluttered and relatively clear band, for short-range communications.
- Demonstration that the Dedicated Short Range Communication (DSRC) equipment will not interfere with satellite communications equipment, which will be sharing a "co-primary" status with DSRC if FHWA's petition to the FCC is granted.

Research and Development--Rural Research (FHWA)

The Rural ITS Research and Development program has been focused on a limited group of projects that are required to ultimately enable public and private agencies to deploy a set of user services that will reduce rural traffic fatalities, increase use and availability of rural transit, and increase rural transportation efficiency.

Current research activities include:

- Evaluating satellite communications systems for Mayday applications.
- Assessing the needs of rural transit operators and transit users.
- Assessing the institutional and technical issues of some of the Rural ITS service groupings.

Key milestones for FY 1998 will likely include:

- Completion of the second of two field projects recommended and conducted under the "Rural Applications of ITS" contract. This consists of the measurement and transmission of real-time delay information to a portable changeable message sign (CMS) at a work zone.
- Initial resolution of some of the critical issues identified in the first assessment of Rural ITS groupings.

Research and Development--High Risk Research (FHWA)

FHWA's High-Risk ITS Research promotes innovative operational and/or analytical tests which have significant potential to help accomplish long-term goals established by the ITS Strategic Plan but do not attract substantial non-Federal commitments because of the level of risk involved.

Major activities for FY 1997 include:

- Completion of 10-15 projects under the *Innovations Deserving Exploratory Analysis* (IDEA) program, with some portion resulting in the successful marketing of an ITS product.
- Completion of approximately 30 research projects on various ITS-related topics.

This research program will end in FY 1997.

Research and Development--Other Research (FHWA)

For a number of otherwise unclassified essential activities and service functions directly related to the ITS research program, fundamental research of a longer term nature is planned, focusing on areas of safety and mobility as they relate to efficiency.

Current research activities include:

- The three ITS Research Centers of Excellence successfully completed their five year ITS research programs, as evidenced by the establishment of continuing programs of ITS funding independent of the Federal grant.
- Five new ITS IDEA products successfully reached the marketplace. Ten other grants were completed. Twenty new IDEA projects were funded.

Key milestones for FY 1998 will likely include:

- Award of three Research Centers of Excellence grants.
- Direct user input on new technology under development as to its ability to meet customer expectations.

Research and Development--Advanced Transit (FTA)

By the very nature of its route structure, fixed route public transit serves a limited segment of the population. It is therefore difficult to expand ridership within that limited market. This research will provide an approach to expand the available market in a cost-effective manner. The objective will be to increase transit ridership by, for example, identifying the degree to which buses should most cost-effectively deviate from fixed routes to serve new customers.

Current research activities include:

- Development of the capability to integrate a vehicle diagnostics system with an existing AVL/CAD (Automated Vehicle Location and Computer Aided Dispatch) system to optimize the potential of the vehicle's wireless data network.

Key milestones for FY 1998 will likely include:

- Guidelines for specifying and deploying flexibly routed fleet management systems with capabilities to include: deviation and flexible routing; real-time passenger counting systems; and guidelines for specifying and deploying flexibly routed fleet management services.

Research and Development--Commercial Vehicle Operations (FHWA)

Commercial Vehicle Operations (CVO) research is focused on SAFER and CVISN activities, which will lead to advanced technology to achieve safe and free movement of trucks and buses throughout North America, and to streamline the regulatory process.

Current research activities include:

- Model deployment of a CVISN system with the capability to support roadside electronic verification and one-stop purchase of credentials.
- Electronic clearinghouses for the International Registration Plan and International Fuel Tax Agreements.
- Software to support carrier-to-State and State-to-State electronic data interchange (EDI) for credentials.

Key milestones for FY 1998 will likely include:

- States deploying CVISN in FY 1998 will have received central support to assist in the software linkages and other technical assistance necessary for successful deployment.

- Completion of the "black box" being developed by Sandia National Laboratories to aid in understanding commercial motor vehicle crashes.
- Completion of the CALSPAN project on visual imaging technology, used to automate the measurement of brake push rod travel in brake testing, reducing the need to employ the manual processes used by inspectors.

Research and Development--Positive Train Control Systems (FRA)

This FRA research effort will explore advanced communication system technologies, and develop and operationally test cost-effective train control systems with the potential to significantly reduce highway-rail intersection (HRI) hazards while minimizing disruptions to highway and rail users.

Current research activities include:

- Complete evaluation of Vehicle Proximity Alert Devices from tests in actual railroad corridors. Summarize each system's strengths and weaknesses and provide suggestions for improvements.
- Continue evaluation of Positive Train Control (PTC) systems in Illinois and Michigan, and of the Positive Train Separation (PTS) system in the Pacific Northwest.
- Evaluate system compatibility between PTS and highway-traffic management systems in the Pacific Northwest high-speed corridor.

Key milestones for FY 1998 will likely include:

- Demonstrate an interactive intermodal traffic control system using the real-time, continuously updated train location data available as a result of implementing advanced communications-based train control systems. Demonstrate that train control and highway traffic management systems correctly communicate with each other.
- Evaluate the effectiveness of techniques such as existing active standard highway traffic signal devices, intersection video surveillance, remote monitoring of detection equipment integrity at grade crossings, traffic advisory and active roadside message devices, devices capable of full blockage of HRIs when necessary for safety, and automated collision avoidance and notification systems.

Automated Vehicle Control and Information Systems (FHWA)

FY	1997	1998	1999
Funding	22,000	26,000	NA
FTE	NA	NA	NA

The Automated Vehicle Control and Information Systems (AVCIS) program is a broad program area which includes the work that has been previously undertaken in the Automated Highway System (AHS) program. The change in program title reflects the emerging focus of current AHS efforts and the focus of the Department on the goal of developing an integrated, human-centered intelligent vehicle which can enhance driving performance and travel efficiency and substantially reduce accidents. In future years, other ITS program work which contributes to this goal (e.g., collision avoidance research and operational tests) will be included in this program area.

Section 6054(b) of the ISTEA legislation established as a goal that the Department of Transportation develop an automated highway and vehicle prototype and demonstrate its feasibility by 1997. In pursuit of that goal, the Department of Transportation entered into a cost-shared cooperative agreement with the National AHS Consortium (NAHSC) in October 1994. Core consortium members include Bechtel, the California Department of Transportation, Carnegie Mellon University Robotics Institute, Delco Electronics, General Motors, Hughes Aircraft, Martin Marietta, Parsons Brinkerhoff, and the University of California Partners for Advanced Transit and Highways (PATH) Program. The NAHSC is responsible for specifying, developing and demonstrating a prototype AHS. That demonstration will take place in the first week of August 1997 on a 7.6 mile stretch of I-15 near San Diego.

This demonstration represents an important milestone in the Department's collaboration with industry to investigate the feasibility of the Automated Highway. However, the Department's social and institutional investigations indicate that it would be unrealistic to pursue an approach that involves new, exclusive rights of way dedicated to automation. Full automation is likely to evolve incrementally from an increasingly intelligent vehicle. This has focused much of the effort on the incremental components of an intelligent vehicle and their user-friendly integration.

An important outcome of the above-mentioned demonstration will be a tighter focus on nearer term features that enhance driving performance and the human factors that are involved with the driver interface. The AVCIS effort is currently a complement to and will ultimately include the ITS Crash Avoidance Program. It extends the benefits achieved from the crash avoidance effort through application of vehicle-to-vehicle and limited vehicle-to-roadside communication and cooperation. Given a shorter focus and the expectation of marketable products, it may be appropriate to have the private sector assume a larger share of the partnership.

Currently, the AHS program is conducting numerous research, development, and testing activities, examples of which include:

- In FY 1997, successful demonstration of AHS proof-of-technical-feasibility will be a major national event showcasing the potential of vehicle-highway automation for 21st century transportation. The demonstration will be conducted on HOV lanes located in the median of I-15 in San Diego, and will integrate basic collision avoidance capabilities with new capabilities in automated vehicle control, with the vehicles and the highway cooperating as a unified system.
- A comprehensive set of institutional/social analyses will yield guidelines for deployment of AHS with respect to land use and sustainable development, an assessment of regional air quality improvements resulting from AHS implementation, guidelines for integrating AHS as a new capability into the transportation planning process, recommendations as to optimal public/private roles in deployment and operations, assessment of AHS operations and maintenance impacts, recommended strategies for mitigating liability, and cost/benefit assessments of AHS concepts.
- Enabling technology R&D is an ongoing activity upon which development of the ultimate AHS prototype will be based. Specific tasks that will be completed in FY 1997 include: initial forward-looking radar build decisions, short-range radar test results, stereo processing for lane and obstacle detection, blind spot sensor test results, color video sensing test results, and definition of critical software validation methods.

Key milestones for FY 1998 will include:

- Continued development of enabling technologies.
- Detailed assessment of user demand and other societal and institutional investigations.
- Results of site-specific case studies.
- Evaluation of the most promising concepts.
- Construction and testing of critical subsystems of the most promising concepts.

The Department of Transportation is in the process of merging all vehicle-focused ITS activities into a multi-agency research and development program, which will be entitled the Intelligent Vehicle Initiative (IVI). The IVI will emphasize the significant and continuing role of the driver in highway safety.

Operational Tests (FHWA)

FY	1997	1998	1999
Funding	54,992	24,500	NA
FTE	NA	NA	NA

ITS Operational Tests address the following areas, each of which are described below in detail: ATMS/ATIS, APTS, CVO, Collision Avoidance, Rural Tests, and Model Deployments.

Operational Tests--ATMS/ATIS (FHWA/FTA)

The goal of ATMS/ATIS Operational Tests is to investigate and evaluate various travel management and technologies standards in a field environment to determine their ability to be integrated, successfully implemented, and to operate with various existing systems and technology.

Current research activities include:

- Testing and integration of various R&D products and standards in a field research test environment, including RT-TRACS and map database standards.

A key milestone for FY 1998 will be:

- Testing of various additional technologies and standards in a field research test environment.

Operational Tests--APTS (FTA)

The goals of FTA's APTS Operational Tests are to extend the benefits of Automated Vehicle Location and Computer Aided Dispatch (AVL/CAD) to small suburban and rural transit operators, and to demonstrate the viability of smart cards that combine the contactless read/write capability desired for transit operation with the contact approach suited for commercial bank cards.

Current research activities include:

- Implementation of Transit Variable Message Sign operational test.
- Implementation of Next-Generation Kiosk and Transit Information operational test.
- Implementation of Advanced Fare Media operational test.

- Implementation of Advanced Fleet Management operational test.

Key milestones for FY 1998 will include:

- An operational test of a Regional Fleet Management system, shared by a number (20-30) of transit agencies within a given region.
- An operational test of a hybrid bank-proximity card.

Operational Tests--Commercial Vehicle Operations (FHWA)

This operational test will bring together individual operational tests such as smart cards, data recorders (black box), emissions checking, and electronic braking systems and link them into a comprehensive system that will warn the driver of faulty systems and send critical information to the roadside to facilitate the electronic inspection of vehicles. The expectation is to allow the driver to voluntarily take a commercial vehicle out of service prior to a mandate by a public safety official, and to improve the vehicle throughput by bypassing the manual inspection process. The test is also expected to develop a drowsy driver detection system that will continuously measure and record driver performance, and using an early warning system to reduce crashes.

Current research activities include:

- Pilot testing the use of onboard sensors and diagnostics to expedite roadside safety inspections of drivers and vehicles.
- Development of a prototype for integrating Smart Card technology, especially for driver safety information.
- Operational tests at the Nogales, Otay Mesa, Santa Teresa, Buffalo, and Detroit border crossings. Border crossing projects in Laredo and El Paso are already underway. Documentation of costs, benefits, and institutional solutions. Refinement of site designs and recommendations for automation at additional crossings.

Key milestones for FY 1998 will include:

- Demonstration of on-board vehicle diagnostics, providing the capability to warn the driver of faulty systems such as lights and brakes, determine compliance status of the carrier, verify emissions at high and slow speeds.

- Assessment of the factors that contribute to commercial motor vehicle accidents and development of applicable monitoring technologies.
- Integration of lessons learned from smart card, black box, and electronic braking operational tests, and development of a pilot model to allow for electronic inspections and driver warnings.

Operational Tests--AVCSS (NHTSA)

NHTSA's operational testing of Advanced Vehicle Control and Safety Systems (AVCSS) facilitates the development and deployment of effective collision avoidance systems and other motor vehicle systems using intelligent technologies to reduce the number of collisions, and ensures that safety is not degraded by new ITS products that may be introduced by automobile manufacturers.

Current research activities include:

- Actual on-the-road testing and data collection on 1,000 vehicles equipped with Automated Collision Notification (ACN) systems.
- Actual on-the-road testing of 10 vehicles equipped with Intelligent Cruise Control (ICC) systems.
- Initiation of on-the-road testing, data collection, and independent evaluation of heavy trucks equipped with ICC.

Key milestones for FY 1998 will include:

- Completion of ACN and ICC Operational Test independent evaluations.
- Continuation of testing, data collection, and evaluation of ICC-equipped heavy trucks.

Operational Tests--Rural (FHWA)

Rural operational testing by FHWA will evaluate the technical and organizational feasibility of ITS to address user needs in real-world rural environments. Examples of potential test categories include speed issues, weather and safety advisories, rural mobility management, and infrastructure-based road departure avoidance.

Current research activities include:

- Completion of Phase I rural user needs case studies in 10 locations to determine ITS deployment planning needs.
- Provision of technical assistance for rural ITS planning.

Key milestones for FY 1998 will include:

- Completion of the evaluation plan for the field operational test initiated in FY 1997.
- Initiation of up to three additional field operational tests.

Evaluation/Program Assessment(FHWA)

FY	1997	1998	1999
Funding	2,000	9,000	NA
FTE	NA	NA	NA

ITS Evaluation includes both Field Evaluations and ITS Program Assessment, which are described separately below.

Evaluation/Program Assessment--ITS Field Evaluations (FHWA/NHTSA/FTA)

Field operational tests of ITS will focus on assessing improvements as measured in six primary measurement areas: (1) reductions in crashes; (2) reductions in fatalities; (3) increases in throughput, (4) reductions in travel time; (5) improvements in customer satisfaction; and (6) savings in public and private sector costs. In addition, the Joint Program Office (JPO) will be working with DOE and EPA to measure energy and emissions impacts of ITS.

Current research activities include:

- Based on the outcome of FY 1996 ITS Field Operational Tests (FOTs), recommended strategies will be developed for completing existing FOTs and beginning new research and FOTs.
- An ITS Program Assessment Support (PAS) contract is expected to yield approximately 20 field operational test evaluation reports, completed Model Deployment evaluation strategy documents, baseline data collection plans, and the initiation of model deployment baseline data collection.

Key milestones for FY 1998 will include:

- Evaluation strategy reports and baseline data collection plans for FY 1998 operational field tests.
- Evaluation baseline reports for intelligent transportation infrastructure Model Deployment sites, CVISN Model Deployment sites, and the Capital Beltway Traveler Information System Showcase.
- Evaluation of final reports from many of the FOTs.

Evaluation/Program Assessment--ITS Program Assessment (FHWA)

In order to evaluate the effectiveness of the ITS program, FHWA carries out a range of benefits estimation and validation activities. These include: canvassing the public and private sectors for benefits with which refinements may be made to hypotheses regarding the national benefits of ITS in term of the six measures identified above; assessing the value of ITS relative to alternative approaches (e.g., adding lanes to highways, reserving lanes for HOVs during peak travel periods); tracking the deployment of partial and integrated ITS throughout the Nation; and assessing the effectiveness of ITS institutionalization.

Current research activities include:

- Collection of ITS empirical measures, and incorporation into simulation models to project benefits of more widely deployed versions of ITS.
- Establishment of an initial set of hypotheses predicting the effectiveness of ITS in a few important measurement areas, based upon benefits assessments using empirical, statistical, and modeling procedures.
- Expansion of the ITS definition of intelligent transportation infrastructure elements into operational definitions that will enable state and local transportation officials to assess their own progress in deploying the intelligent transportation infrastructure. National progress toward achieving stated policy goals to deploy intelligent transportation infrastructure over the next decade will be reported.

Key milestones for FY 1998 will include:

- Documentation of early benefits and lessons learned from case studies of the design, building, and early implementation phases of Model Deployment sites.

- Completion of modeling predictions of ITS effects in Model Deployment site areas, based upon baseline data collected in FY 1997 and FY 1998.
- Analysis of questionnaire data on early indicators of customer satisfaction with CVISN and intelligent transportation infrastructure Model Deployments.
- Publication of a refined set of hypotheses regarding quantitative goals for the effectiveness of ITS.
- Completion of a longitudinal study of economic benefits of ITS across select U.S. cities.

Architecture and Standards (FHWA)

FY	1997	1998	1999
Funding	5,000	13,000	NA
FTE	NA	NA	NA

ITS Architecture and Standards provides for the development of ITS Architecture and ITS Standards, discussed below in detail.

Architecture and Standards--Architecture

In order to ensure the rapid and widespread deployment of ITS systems and components on a nationwide basis, an ITS National System Architecture was completed in July 1996, describing how the various ITS systems and components will smoothly interact with each other. This architecture, which is to be developed as a fully consensual process, will guide -- and not mandate -- consistent decisions among investors, producers and purchasers of ITS products and services so that the risk of incompatibility is minimized. 1997 is the trial year for getting the architecture out into the hands of implementors. Until such time as all the required standards are published and catalogued to provide implementors with appropriate technical direction, revision of the technical information in the architecture will provide an important design reference for cities and states, and will help to insure that current implementors don't repeat the mistakes made by earlier adopters.

Current research activities include:

- Assisting standards development organizations in the development of ITS standards. Providing insight into national/regional interoperability aspects of the architecture standards requirements documentation.

- Completion and distribution of the ITS user documents. Support to Model Deployments to ensure adherence to the national architecture.
- Incorporation of the Highway-Rail Intersection user service into the national architecture documentation.

Key milestones for FY 1998 will include:

- Assisting standards development organizations (SDOs) in the development of ITS standards that were identified in the national architecture.
- Continuing the update of the architecture as a result of deployment experience.
- Beginning translation of the maintenance of the architecture to the appropriate standards organization. Development of an architecture maintenance transition plan to effect ITS interface definition maintenance to the standards development community.

Architecture and Standards--Standards (FHWA/FTA)

The objectives of the standards program are to provide an environment in which public sector agencies and others have multiple vendors from which to choose; to promote the creation of an ITS market through interoperability of multiple vendor products; to ensure safety through standards for human factors and operational guidelines; and to facilitate the deployment of integrated systems.

Current research activities include:

- Making a wide range of ITS standards available for operational use, examples of which include: a protocol for dedicated short-range communications (DSRC); Electronic Data Interchange (EDI) standards for roadside electronic verification and purchase of credentials; and standardized message sets for automatic vehicle identification, vehicle navigation, and Mayday messages.
- The National Transportation Communications for ITS Protocol (NTCIP) will deliver the final message format specifications for traffic signal control and variable message sign devices, as well as complete initial message format specifications for roadway weather information systems, closed circuit television, and highway advisory radio devices.
- Initiation of approximately 10 additional activities in the areas of message set and foundation standard identified as high priority areas by the architecture.

Key milestones for FY 1998 will include:

- Initiation of activities for the remaining message set standards currently defined by the architecture.
- Provision of approximately 10 additional standards for operational use.
- Assistance in training public sector agencies in the utility and use of the ITS standards.
- Requirements for standardizing the efficient processing of time-varying transit information on a Geographic Information System (GIS).

Mainstreaming (FHWA)

FY	1997	1998	1999
Funding	0	22,000	NA
FTE	NA	NA	NA

ITS Mainstreaming activities will include: Technical Assistance, Planning/Policy initiatives, Training, and Awareness and Advocacy. Mainstreaming activities in each of these areas are discussed below.

Mainstreaming--Technical Assistance (FHWA/FTA)

DOT has been assisting state and local officials and private sector participants in the development of plans for "early deployment" of ITS products and services for commercial vehicle safety regulations and travel management. In the CVO area, this has included supporting states in the development of CVO deployment business plans, holding regional forums and supporting institutional and technical studies which help the CV community -- both public and private -- to understand ITS programs and benefits and be prepared to incorporate them into their ongoing activities.

Technical assistance related to mainstreaming includes transferring the results of ITS research and development, operational tests, and Model Deployment efforts; sharing the lessons learned in overcoming institutional barriers and enhancing interjurisdictional cooperation; and providing national leadership in the reengineering of current business practices by States and motor carriers.

Current technical assistance activities include:

- Establishment of the ITS Assistance Network (ITSAN) designed to provide "real world" technical assistance through a "peer-to-peer" information exchange on intelligent transportation infrastructure deployment issues and problems associated with state and local agency technical personnel in both highway and transit fields.
- Provision of direct technical assistance to transit authorities in the design, development, procurement, and implementation of ITS. Completion of preliminary investigation and data collection on the integration of transit fare collection and stored value bank cards.
- Completion of study of legal, security, and privacy issues related to CVO, especially onboard systems.

Key milestones for FY 1998 will include:

- Showcasing intelligent transportation infrastructure components and integrated systems at the Model Deployment sites to elected officials and transportation professionals through a variety of scanning reviews and "distance learning" information sessions.
- Provision of technical guidance to border States as they implement the international border clearance program.
- Presentation of approximately 70 seminars and workshops covering lessons learned and best practices, along with technical project guidance.

Mainstreaming--Planning/Policy (FHWA)

Planning initiatives are undertaken by state and local governments in 40 metropolitan areas to enhance system performance through the integration of system planning and system operations. By providing technical, best practices and guidance materials to over 400 state and local planning organizations, FHWA can facilitate the consideration of ITS and congestion management options within the context of regionwide multimodal transportation planning.

Current activities include:

- A pilot effort to provide funding to two metropolitan planning organizations (MPOs) and one state transportation department to support the startup of regionwide congestion mitigation and system operations initiatives.

- A guidebook to expand the capacity of MPOs to consider the mobility impacts of accident/incident-induced congestion and the ITS-related tools available to speed response and clearance activities.
- Updating *Integrating Transportation Planning and ITS--An Interim Handbook* to provide better ITS effectiveness evaluation tools.

Key milestones for FY 1998 will include:

- Initiation in 40 areas of a program supporting local initiatives to merge transportation system operations with the system planning functions.
- Development and distribution of rural intelligent transportation infrastructure program guidance materials.
- Availability to state and local transportation planners and decision makers of information on the costs, benefits, and impacts of deploying congestion management and intelligent transportation infrastructure strategies.

Mainstreaming--Training (FHWA/FTA)

ITS Mainstreaming activities include an intensive and focused ITS training program for professional capacity building to state and local transportation personnel. The objective is to train public sector professionals to a level of expertise commensurate with their duties and responsibilities in the planning, design, implementation, operation, and maintenance of current and future ITS projects.

Current training activities include:

- Development of a five year business plan for implementing the training objectives set forth in the Strategic Plan for ITS Professional Capacity Building.
- Pilot testing and presentation of two ITS short courses: "Transit Management Systems" and "Regional Transportation Information Systems".
- Training for States/carriers on how to automate the collection, reporting, and auditing of electronic mileage and fuel records by State.

Key milestones for FY 1998 will include:

- Initiation of delivery of training to over 4,000 state and local officials and transportation professionals over a two year period.

- Provision of 100 university scholarships to encourage young professionals to enter ITS-related fields and seek employment in Federal, State, and local transportation management agencies.
- Provision of ITS technician training modules, supporting professional certification programs through "distance learning" and computer-based techniques to those who cannot afford to travel to receive needed training.

Mainstreaming--Awareness and Advocacy (FHWA/FTA)

This ITS activity increases the awareness, involvement, and understanding of ITS--its benefits, its capabilities, and its operations--among public officials, stakeholder groups, and the general public.

Current awareness and advocacy activities include:

- Provision of ITS support information, presentations, and other material to assist field offices in their efforts to promote deployment of intelligent transportation infrastructure components.
- Support information and ITS advocacy needs and exhibits at approximately 10 major events during FY 1997.
- Delivery of over 100 seminars and short courses on various ITS topics to U.S. DOT headquarters and field office staff during FY 1997.

Key milestones for FY 1998 will include:

- Awareness and advocacy programs will emphasize the capabilities and benefits of intelligent transportation infrastructure systems and technologies in meeting regional transportation needs.
- A major campaign will be initiated to increase public awareness of traveler information services that can be used while considering travel mode options and routes in advance of making routine and special trips.

ITS Program Support (FHWA)

FY	1997	1998	1999
Funding	7,761	10,000	NA
FTE	NA	NA	NA

The Program Support function provides for the central coordinating role of the U.S. DOT in the ITS program. This role includes facilitating the development of a National consensus among public and private sector participants on the goals, plans and progress of the ITS program, as well as ensuring that the various ITS activities receive proper technical review and integration.

This function also supports the Cooperative Agreement with ITS AMERICA, a chartered Federal Advisory Committee, for program planning and assessment; and support for MITRE Corporation to provide the Department with program management and system engineering services in support of the ITS program. Additionally, it provides for information management support, local area network services, and technical and program advice in specific areas such as advanced traffic management system applications and system architecture.

Current program support activities include:

- Technical support on issues relating to standards development and radio frequency spectrum acquisition and auctioning, and analytical work that addresses the benefits and costs of various ITS services.
- Technical and program policy advice on specific topics, including advanced traffic management applications and system architecture development, under service contracts with experts in selected program areas.

Key milestones for FY 1998 will include:

- Activities, both internal and external to DOT, that support development of consensus or decisions on critical ITS program issues.
- Technical review to analyze and coordinate technical information as required in support of the Advance Public Transit Systems Program.

ISTEA Section 6058 Funds (FHWA)

FY	1997	1998	1999
Funding	113,000	0	NA
FTE	NA	NA	NA

Through fiscal year 1997, Section 6058 of ISTEA authorizes the appropriation of up to \$113 million per fiscal year for the ITS (formerly, IVHS) Corridors Program established under Section 6056, and for other ITS activities. The ITS Corridors Program is intended to stimulate the application of ITS technologies to corridors in which their application will have particular benefit, and is focused upon those with the following characteristics: (1) high traffic density, (2) severe or extreme nonattainment of U.S. standards for ambient ozone concentration, (3) a variety of transportation facilities, (4) constraints to physical infrastructure expansion, (5) a significant mix of passenger, transit, and commercial motor carrier traffic, (6) complex traffic patterns, and (7) potential contribution to implementation of the Department's Strategic Plan for the ITS program. The allocation of Section 6058 funds to other areas is authorized based on potential improvements in operational efficiency, commercial productivity, safety, and motorist and traveler performance, and on reductions in regulatory burden.

ITS Deployment Incentive Program (FHWA)

FY	1997	1998	1999
Funding	0	100,000	NA
FTE	NA	NA	NA

As is discussed above, the Department has formed an ITS deployment strategy for the next decade which has as its primary goals (1) full implementation of intelligent transportation infrastructure in 75 of the Nation's largest metropolitan areas, (2) deployment of CVISN in all interested states, and (3) upgraded intelligent transportation infrastructure technology in 450 rural communities and the NHS. While it is appropriate that ISTEA provide greater flexibility for local decisions on the operations and enhancements of *existing* systems, these goals represent a new layer of infrastructure that will enable intermodal systems management, to achieve efficiency gains needed to accommodate future travel demand and global commerce. The promise of intelligent transportation infrastructure and CVISN can be realized only if they are implemented as national systems, using common standards and a common architecture.

Full achievement of the Department's goals for intelligent transportation infrastructure and CVISN deployment would require a new annual set-aside of \$1 billion. By targeting initial funding of \$100 million in FY 1998 towards deployment of integrated intelligent transportation infrastructure and CVO elements in both metropolitan and rural areas, the Federal government can make important progress toward attainment of the critical mass necessary to accelerate standards and meet other program objectives.

GPS Support (FHWA)¹²

FY	1997	1998	1999
Funding	0	2,100	NA
FTE	0	NA	NA

The Department of Transportation has worked with the Department of Defense via the GPS Joint Program Office (GPS JPO) to add an option to the Block IIF satellite contract for a second civil frequency (called L5). The addition of L5 to the GPS satellites will allow civilian users of the system to obtain greater accuracy than available with the existing single frequency. In the area of differential or augmented GPS, a preliminary assessment of the technical feasibility of expanding the USCG system to cover the remainder of the U.S. has been completed, and a final report will be completed shortly. Work on an implementation plan has also commenced.

The funds requested for FY 1998 represent half of the estimated cost in FY 1998 to perform this work.

Crash Avoidance--Driver/Vehicle Performance (NHTSA)

FY	1997	1998	1999
Funding	1,000	1,000	NA
FTE	2.0	2.0	NA

This program's goals are to help drivers of all types of vehicles avoid crashes or to lessen the severity of crashes that do occur by: improving driver direct and indirect visibility; improving tire traction performance; improving vehicle braking, directional, and rollover stability; improving vehicle lighting, signaling, and marking; ensuring compatible driver/vehicle interfaces; developing objective test procedures for collision avoidance systems; and acquiring, archiving, and making available to customers driver/vehicle performance characterization data. Research activities include the following:

- Continue research into the performance of antilock braking systems of light vehicles; assessment of driver reaction and driver feedback to activation of the antilock feature; assessment of brake performance on various surfaces;
- Develop protocols for combining simulator and test track experimental data into objective test procedures that could serve as the basis for performance-based standards or regulations;

¹²GPS Support is classified as a Physical Infrastructure research activity.

- Conduct research into issues associated with vehicle rollover such as developing a methodology for determining critical characteristics of vehicles and developing test procedures for demonstrating the impact on vehicle stability and rollover propensity; and
- Provide support for collision avoidance rule making activities on an as-needed basis.

A key milestone for FY 1998 will be to complete evaluation of the interaction between drivers' actions and antilock braking system performance.

Grade Crossing Research (FRA)

The goal of FRA's grade crossing research activities is to develop, characterize, and demonstrate technologies that can reduce the frequency of accidents at railroad grade crossings. Current priorities include:

- Using driver behavior models to devise improved crossing warning and control systems.
- Demonstrating a comprehensive approach to minimizing hazards on a developing high-speed corridor; testing in-cab warning systems; mitigating poor ride quality and reducing high track-train forces at chronic problem track locations.

For FY 1998, key milestones will include:

- Providing new technologies in grade crossing and noise measurement systems.
- Achieving full corridor coverage for a "Sealed Corridor" demonstration on the Charlotte-Raleigh corridor in North Carolina.

Industry Competitiveness (MARAD)

FY	1997	1998	1999
Funding	0	0	NA
FTE	NA	NA	NA

One of the responsibilities of the Maritime Administration is to foster the development of a competitive U.S. maritime industry that contributes to both the Nation's economic growth as well as important National security goals. A top priority of MARAD's Industry Competitiveness program is to assess and deploy effective and innovative information, communications and navigation systems and technologies that will improve the efficiency, productivity and safety of the National maritime transportation system.

In pursuit of this goal, MARAD has expanded participation by the maritime industry in the Ship Operations and Cargo Handling Cooperative Programs, which facilitate the development and sharing of new technologies in these fields. Both of these government/industry cooperative efforts are industry-led and cost-shared. One current project is the development of an integrated Reliability Availability Maintainability Database (RAM) designed to collect ships' equipment failure/corrective maintenance data. The U.S. maritime industry, and foreign fleets as well, have a worldwide need for such a database which can be achieved only with Government participation and leadership.

This program also assesses advanced information systems designed to improve vessel operating safety and efficiency, and conducts research on innovative cargo handling equipment, techniques and systems. The program has also supported the development of these technologies, such as a shipboard Personal Computer-based training system for ship crews. Finally, designated National Maritime Enhancement Institutes will participate in these activities as appropriate.

Hazardous Materials Research (RSPA)

FY	1997	1998	1999
Funding	1,161	1,167	NA
FTE	2.2	2.2	NA

RSPA's hazardous materials safety (HMS) program is a comprehensive nationwide safety program to protect the Nation from the risks to life, health, property, and the environment inherent in the transportation of hazardous materials by water, air, highway, and railroad; to protect the environment from damage by oil and other pollutants; and to ensure the safe transportation of food. The research and development program provides the technical and analytical foundation necessary to support DOT's regulatory, international standards development, compliance, and emergency response activities in the area of hazardous materials (HM) transportation safety. Current research and development efforts are organized into three program areas:

- Information Systems - Continuing to refine the intermodal database; integrating registration data into the Hazardous Materials Information System (HMIS); and assessing the feasibility of enabling industry to file incident reports electronically.
- Research and Analysis - Completing a general risk assessment of HM transport by hazard class, quantity, and packaging; and completing over 12 projects on a range of specific HM risk assessment and technology issues.
- Regulation Compliance (Testing) - Continuing contractor package testing.

Major milestones for FY 1998 will include:

- An assessment of the technical needs for receiving incident report data in electronic form.
- Analytical support for basic rulemaking activities including preparation of regulatory evaluations and related risk-based assessments.

Emergency Transportation (RSPA)

FY	1997	1998	1999
Funding	68	69	NA
FTE	NA	NA	NA

The Office of Emergency Transportation, located in RSPA, provides the Secretary of Transportation and senior DOT officials with an effective ongoing emergency response capability within the overall interagency context of the Federal Response Plan (the Federal Government's plan for performing disaster assistance missions). The Response Management Support program is responsible for maintaining and enhancing the Department's ability to provide these decision-makers timely information in the event of a crisis. In particular, this effort focuses on the ability to assess the effects of a natural disaster on the National transportation system, as well as effective tracking of the flow of critical relief supplies during the response phase. This activity researches available crisis management software systems, including mapping and communications capabilities, and implements improvements to them.

Related Departmental Activities

Aviation Satellite Navigation (FAA)

The Federal Aviation Administration's Navigation program, includes two major program elements. The first element, Satellite Navigation, supports the operational use of satellite navigation technologies such as the Global Positioning System (GPS) and the International Marine Satellite (INMARSAT) in civil aviation. A number of ITS concepts and systems also utilize GPS for surface navigation and vehicle location purposes. The second element, Navigation Systems Development, identifies and evaluates new navigation technologies and concepts that may be applicable to civil aviation. This includes assessing the feasibility of transitioning from primarily ground-based to satellite-based navigation systems, and contributing to the updating of the Federal Radionavigation Plan (FRP).

Improve Search and Rescue Capability (USCG)

The U.S. Coast Guard is the leader in maritime search and rescue. The speed with which USCG responds, and the effectiveness of its search tools and methods directly affects the probability that it will successfully locate persons and vessels in distress. Recent efforts to improve these capabilities include: evaluation of new laser illuminator technology to increase the effectiveness of night vision goggles; heavy weather tests of GPS/Argos self-locating datum marker buoys used to define search area movement; and a feasibility study of using advanced very high resolution radar satellite image data to provide ocean current surface data for computer-assisted search planning. Near-term priorities include: improved statistical tools for search planning; modeling of multi-sensor searches and multiple searches in the same area; and investigating the potential use of satellite altimeters and wind/wave scatterometers for obtaining near real-time sea surface wind and current data.

Waterways Safety and Management (USCG)

One of the primary responsibilities of the U.S. Coast Guard is to facilitate the safety and efficient use of the Nation's waterways. Towards this end, the USCG's Waterways Safety and Management program investigates and applies new and emerging navigation, communications, display and information systems technologies to marine navigation. These activities include continuing the development and enhancement of the Advanced Vessel Traffic System (VTS), developing a ship transit risk model, as well as assessing new concepts for buoys, navigational lights, and other short-range aids to navigation. The program also supports the implementation of International Maritime Organization (IMO) standards for Electronic Chart Display Information Systems (ECDIS) and Electronic Nautical Charts within the U.S.

Improve Maritime Law Enforcement Capability (USCG)

USCG has a significant role as a law enforcement agency to reduce the flow of illicit drugs and alien migrants to our shores, and to protect our fishing grounds by enforcing national and international fishing laws and agreements. To improve its law enforcement capabilities in an era of increasing sophistication on the part of traffickers, the USCG conducts research to improve its surveillance and vessel search processes, and its nonlethal compliance processes. Specific research activities include: defining capabilities and limitations of candidate remote sensing equipment, developing data fusion techniques for sensor queuing, developing synthetic imagery for fuses data from multiple sensors, and integrating data from multiple sensors in a single display for real-time use and decision support.

Command, Control, Communications, Computers, and Intelligence Integration (USCG)

USCG decision makers at all levels of command need timely and accurate information. Advances in information and communications technology provide the opportunity for development of integrated Command, Control, Communications, Computer, and Intelligence

(C4I) systems, which will provide these officials with more timely information through state of the art technology. Specific USCG research priorities in this area include: integrating USCG operational databases, developing future mobile communications requirements, investigating satellite communications architecture for wide area network capability between mobile platforms and shore units, investigating commercial communications initiatives, and developing system simulations of proposed National Distress System (NDS) replacement systems to validate performance and ensure interoperability.

It is a great pleasure to hear from you and to learn that you are well. I am also well and hope this letter finds you the same. I have been thinking of you often and wondering how you are getting on. I hope you are enjoying your work and life. I am sure you are. I am looking forward to hearing from you again soon. I am sure you will have many interesting things to tell me. I am sure you are. I am looking forward to hearing from you again soon. I am sure you will have many interesting things to tell me.

CHAPTER 4

NEXT-GENERATION VEHICLES AND FUELS

Transportation vehicles are a major element of our transportation system. In fact, transportation's performance, safety, security, cost, environmental impact, economic consequences, and contributions to quality of life are all determined largely by the vehicles that carry people and goods. Today, our transportation system faces several major challenges that are directly related to vehicles and fuels: increased global competition for our transportation industries, economic exposure to fuel price instability, attainment of the National Ambient Air Quality Standards (NAAQS), reduction of greenhouse gas (GHG) emissions, and increased demands for mobility from our citizens. Meeting these challenges will require a next generation of vehicles and eventually, fuels, that meet rigorous standards for reliability, cost, safety, energy use, and environmental impacts. Thus, a strategic goal for transportation R&D is enhancing the overall performance of vehicles of all types, while expanding the range of available alternatives.

Unlike physical infrastructure improvements, a large number of which the Government is responsible for, vehicle technology improvements are achieved through long-term R&D that optimizes and leverages the use of both public and private resources. Federal investment is needed to reduce the risk to the private sector and to assure a continuous flow of innovation.

In its Strategic Planning Document for 1995, the NSTC Committee on Transportation R&D identified a number of major program objectives for transportation vehicle R&D. Among these are the following:

- *Develop a personal motor vehicle that will deliver up to three times the fuel efficiency of today's comparable vehicles while reducing emissions, without compromising performance, safety, room, and utility.*
- *Develop and introduce manufacturing technologies and practices that will reduce the time and cost associated with designing and mass-producing this new personal motor vehicle.*
- *Improve and regain the U.S. position in the world truck and bus market.*
- *Assure that advanced truck and bus technologies consider accessibility, energy efficiency, and environmental impacts.*
- *Facilitate innovation in rail vehicle design and construction by introducing advanced materials, communications, and control technologies.*

- *Improve the propulsion and emission performance of intercity and commuter locomotives, and expand the range of alternatives available to meet future transportation needs.*
- *Develop strong and competitive international ocean shipping and domestic water transportation industries.*
- *Develop a strong and competitive commercial ship design and production capability.*

Near-Term Efforts

The majority of DOT's near-term vehicle research is aimed at meeting the transportation committee's objectives. Specific programs are discussed below:

Motor Carrier Research (FHWA)

FY	1997	1998	1999
Funding	7,399	8,541	NA
FTE	9	9	NA

The Office of Motor Carriers' (OMC) research program includes the following: (1) human factors research on commercial driver alertness, medical fitness, drug and alcohol use, and driver licensing and training (discussed in Chapter 5, below); (2) evaluation and promotion of safety-enhancing vehicle and data-reporting technologies; (3) establishing and undertaking program analysis activities; (4) undertaking a comprehensive, multiyear regulatory review to make regulations more enforceable, understandable, and performance-based; and (5) creating more opportunities for innovation, partnerships, and shared financing in the pursuit of OMC research objectives. Non-driver-related OMC research includes:

- **Technology** — Review ITS technologies to determine near-term applications for improving motor carrier safety and productivity. Determine the effectiveness of various technologies and their impact on the operations of multiple-trailer commercial vehicles. In coordination with NHTSA, assess feasibility of alternative braking technologies (e.g., electric), as well as recommendations for the marking and identification of commercial motor vehicle replacement parts and accessories. Assess the feasibility of standards for "after market" brake linings and other brake system components.
- **Information Analysis** — Implement a system to improve the validity and reliability of information in the motor carrier Census File update. Analyze the effectiveness of fines and penalties, as well as technical assistance and education programs, in achieving motor

carrier and driver compliance with safety regulations. Evaluate the characteristics of reported crashes by different motor carrier operations, vehicle types, crash locations, and other pertinent factors.

- **Services and Partnerships** — Continue efforts to develop and implement new, cost-effective reporting, recordkeeping, and registration procedures.
- Creating more opportunities for innovation, partnerships, and shared financing in the pursuit of its research objectives.

Major milestones for FY 1998 will include the identification of potential technologies for rapid and reliable roadside inspection activities, and the development of an effective interface between SAFETYNET and ITS data systems.

Safety Systems (NHTSA)

FY	1997	1998	1999
Funding	6,488	8,338	NA
FTE	16.01	16.02	NA

Frontal, side, and rollover crashes account for most of the deaths and injuries to occupants of passenger cars and light trucks and vans. Ejections, pedestrian impacts, and fires also cause death and injury. The goal of this research is to provide improvements in vehicle structure and occupant compartment design, in combination with improvements in restraint systems. These improvements require research in test procedures, injury likelihood measurement, and countermeasure development and evaluation. A second goal is to foster international harmonization in the pedestrian, frontal offset, vehicle compatibility, and functional equivalence research areas, including the following:

- Evaluating the reliability of rollover test procedures.
- Analyzing the feasibility of modeling the early phase of air bag deployment.
- Continuing to update and maintain the vehicle attributes crashworthiness database.
- Continuing to test various impact configurations.
- Evaluating designs of modified vehicles to establish the effectiveness of side-impact countermeasures.
- Using the developed seat model, investigate countermeasures that would mitigate whiplash and other injuries.

- Continuing work on a near-term, economical crash sensor to reduce occupant injuries.
- Continuing R&D on advanced air bag systems.

A milestone for FY 1998 will be to evaluate production vehicles and develop countermeasures for improved frontal crash protection.

Biomechanics (NHTSA)

FY	1997	1998	1999
Funding	7,437	10,587	NA
FTE	8.54	8.54	NA

Within the framework of the newly established National Transportation Biomechanics Research Center, biomechanical research efforts will continue to build on the program of increasing our biomechanical understanding of the impact injuries and developing technologies that will reduce impact injuries on the Nation's highways. These efforts will expand the Department's expertise and capability in the area of impact biomechanics, improve and promote the use of biomechanics in all transportation modes, as well as adapt this technology to impact safety efforts within both the civilian and military sectors. NHTSA's Biomechanics research program pursues efforts that (1) study physical conditions and human consequences of real-world crashes with multidisciplinary teams of medical, engineering, and crash investigation professionals; (2) provide a detailed understanding of the forces, motions, and distortions the human body experiences in a crash and their relationship to the extent and severity of resulting injuries; (3) create detailed computer models of the human body that can simulate human impact response and trauma; and (4) develop and improve dummy components and other mechanical trauma assessment devices that evaluate human impact risk. Ongoing efforts include:

- Conducting hospital-based, in-depth crash injury studies at four trauma centers.
- Continuing experiments to increase public safety with better seat belt and air bag systems.
- Conducting experiments to increase public protection in side impacts.
- Continuing experiments to determine neck trauma and validate neck computer model.
- Continuing to develop human thorax computer model.
- Continuing upgrading and updating of existing crash dummies.
- Studying brain trauma resulting from crashes.

A major milestone for FY 1998 will be computer linkage of detailed hospital-based injury studies completed and on-line. Efforts of existing centers coupled with efforts of additional three centers maintained by independent funding. Applicability of research in biomechanics to multiple modes will be actively pursued by NHTSA.

*Partnership for a New Generation of Vehicles
(NHTSA)*

FY	1997	1998	1999
Funding	2,496	2,496	NA
FTE	0.00	0.00	NA

This NHTSA program provides technical support for the Administration's Partnership for a New Generation of Vehicles (PNGV) initiative. As the focal point within DOT for the PNGV program, the goal of the research is to ensure that the PNGV-developed vehicles will meet existing and anticipated safety standards and that the overall crash and other safety attributes are not compromised by their light weight or use of new advanced materials used in production of these vehicles. Ongoing work will:

- Continue to develop advanced computer models to evaluate the crashworthiness of conceptual designs.
- Continue research in the area of lightweight materials such as advanced composites. Develop new, unique material models for use in the FEM code.
- Provide the required PNGV transportation infrastructure analyses.
- Provide peer review study of the conceptual designs.

A key FY 1998 milestone will be to continue to develop analytical capability to support the PNGV program.

Heavy Vehicles (NHTSA)

FY	1997	1998	1999
Funding	595	595	NA
FTE	7.47	7.48	NA

The goals of this research effort are to reduce the Nation's health care costs by improving heavy vehicle crash avoidance and crashworthiness capabilities, e.g., better braking, enhanced dynamic stability and improved occupant crash protection. Heavy vehicles constitute 3 percent of the vehicle population, accumulate 7 percent of the vehicle miles traveled, but are involved in 13 percent of all fatal crashes. Most of these fatalities (approximately 4,000 each year) are occupants of smaller vehicles involved in collisions with heavy trucks. This represents more

than 25 percent of the light vehicle occupants who are killed annually in two-vehicle collisions. Near-term research includes the following:

- Complete a cooperative program with industry to develop braking stability performance test procedures for air-braked trailers in support of rulemaking.
- Expand joint efforts with industry to develop information and data needed by government and manufacturers to further improve truck safety performance through the use of electronic braking.
- Continue feasibility assessment of methods for reducing the severity of truck/car frontal collisions.
- Continue to foster the application of advanced technology to improve the collision avoidance performance of heavy vehicles.

An FY 1998 milestone will be to complete evaluation of test procedures to measure friction properties of heavy vehicle brake linings.

Equipment, Operations, and Hazardous Materials Research (FRA)

FY	1997	1998	1999
Funding	5,545 ¹³	5,509 ¹⁴	NA
FTE	5	5	NA

This FRA program is designed to improve safety and enhance productivity within the railroad industry by reducing accidents caused by unanticipated and catastrophic equipment failure, inefficient or ineffective operations, and the inadvertent release of hazardous materials.

Current activities, which emphasize technologies to identify defects well before failure and to ensure safe operations at higher speeds, include the following:

- Equipment - Evaluating wheel stress nondestructive evaluation (NDE) techniques; completing "end user" development of a wheel defect detection device; validating the performance specifications of advanced braking systems; completing the preliminary analysis of cab car crashworthiness; and completing the preliminary dynamic performance specifications of conventional passenger vehicles.

¹³Includes \$2,000k for FRA Human Factors research.

¹⁴Includes \$2,000k for FRA Human Factors research.

- **Hazardous Materials** - Completing studies on tank car/lading compatibility; completing Phase I of the stub sill fatigue crack growth study.

Major FY 1998 milestones will include:

- Publication of results of evaluation of an improved roller bearing wayside inspection method.
- Publication of the tank car 15,000 mile service loads measurement report.

Safety of High-Speed Ground Transportation (FRA)

FY	1997	1998	1999
Funding	4,600	5,250	NA
FTE	1	1	NA

The goals of this FRA program are to provide validated technologies and data bases to support FRA rulemaking related to high-speed rail safety; to develop new inspection technologies to monitor the safety performance of high-speed passenger rail equipment; and to provide an knowledge base for public and private decision making related to high-speed rail systems.

Current research efforts include:

- Developing crash energy management concepts for occupant protection.
- Assessing the adequacy of track strength under loads from high cant deficiency (tilt) operations.
- Evaluating the actual safety performance of prototype high-speed positive train control systems.

Major milestone for FY 1998 will include:

- Providing technical evaluation of the Florida/FOX high-speed rail system and technical support to the Amtrak high-speed trainset under development.
- Updating fire safety guidelines and evaluation methods.
- Completing passenger seat impact test and evaluation.

Next-Generation High-Speed Rail (FRA)

FY	1997	1998	1999
Funding	26,176	19,595	NA
FTE	4	4	NA

This FRA program's goal is to develop, demonstrate, and validate cost-effective high-speed (125-150 mph) passenger rail technology that operates on existing infrastructure in the U.S., to reduce per-mile upgrade costs from about \$10 million to \$2-3 million, and to make proven high-speed rail technologies available to States for implementation by the year 2000. Current research activities include:

- Non-Electric Locomotives - Demonstrating the operating and maintenance characteristics of new locomotive designs; demonstrating the operability of flywheel energy storage in the laboratory; testing active locomotive noise control.
- Planning Technology - Updating and integrating user-friendly high-speed rail operational and economic performance computer forecasting models for State planning.

For FY 1998, key milestones will be include:

- Incorporating flywheel system into a locomotive and preparing for testing.
- Evaluating revenue service performance of advanced nonelectric locomotives in one or more corridors.

Shipyard Revitalization (MARAD)

FY	1997	1998	1999
Funding	0	0	NA
FTE	NA	NA	NA

This program addresses the implementation and execution of President Clinton's Plan entitled "Strengthening America's Shipyards: A Plan for Competing in the International Market." In support of this initiative, the Congress enacted legislation on November 30, 1993, containing the National Shipbuilding Initiative (NSI). This legislation serves as a catalyst for promoting construction of ships in U.S. shipyards as part of the transformation from a primarily military focus to one serving the international commercial marketplace. Goal 3.7 of the DOT's Strategic Plan commits the Department to "Implement the President's new shipbuilding initiative to enable American shipbuilding to be more competitive globally." As the U.S.

Government's commercial shipbuilding advocate, the Maritime Administration is undertaking the initiatives identified in the President's program. These are:

- Ensuring Fair International Competition
- Improving Competitiveness
- Eliminating Unnecessary Government Regulation
- Financing Ship Sales through Title XI Loan Guarantees
- Assisting International Marketing

An important milestone for FY 1998 will be to continue the implementation of these National goals. The full implementation of the mission of the Maritime Administration's National Maritime Resource and Education Center will provide the industry with: a coordinated administration of MARAD MARITECH funded projects designed to improve shipbuilding processes and the development of new and improved ship designs; support for U.S. efforts at reaching consensus on domestic and international standards and regulations affecting the competitiveness of the U.S. maritime industry; access to comprehensive Marine Standards and International Standards Organization (ISO) 9000 and 14000 information; and MARAD sponsored topical seminars, training and other resource support as requested by the industry.

Given sufficient funding, another element for consideration is the Ship Structure Cooperative Research Program. The goals of this cooperative research program are to investigate ship structural problems, pursue new technology, and develop structural design, analysis and fabrication techniques in areas of common interest. The research is defined and directed by the Ship Structure Committee with assistance from the Committee on Marine Structures, Marine Board of the National Research Council. The Ship Structure Committee is jointly funded by participating agencies, which include the Maritime Administration, the U.S. Coast Guard, the Military Sealift Command, the U.S. Navy, the American Bureau of Shipping, Transport Canada, and the Canadian Defense Research Establishment. MARAD is unable to contribute funds in 1997, but has been allowed to continue to participate in the Cooperative's program decision making process.

Key milestones for the Ship Structure Cooperative Research Program include: the completion of research on hull monitoring systems, visual detection of structural defects, weld repair adequacy, corrosion control during fabrication and improved fatigue life of weld details; and the awarding of contracts for new research in the Ship Structures Cooperative Research Program as chosen by U.S./Canadian government participants.

New Bus Vehicles and Infrastructure (FTA)

FY	1997	1998	1999
Funding	6,500	11,000	NA
FTE	NA	NA	NA

This FTA program aims to improve the safety, service, and cost-efficiency of public transportation through research and adoption of new technology, management practices. The program also emphasizes the introduction and safe use of alternative fuel buses. The program will develop and demonstrate new vehicles and vehicle technologies that significantly lower operating and maintenance costs and improve air quality, and will foster the commercialization of these new technologies. FY 1998 program activities include the following:

- Complete prototype construction and field testing of the Advanced Technology Transit Bus (ATTB), initiate work on development and deployment of advanced technology subsystems for transit buses, and provide engineering support for the new bus model testing program in Altoona. The ATTB utilizes light-weight materials, advanced structural design, and new passenger information systems and electronics and consumes less fuel, thus lowering operating costs. The ATTB will also meet clean air emission standards, and its no-steps, low-floor design will provide improved access to persons with disabilities.
- The Demonstration of Universal Electric Subsystems (DUETS) program is developing and testing an advanced alternatively fueled electric-hybrid drive system, advanced suspension components, and advanced vehicle control networks for transit bus applications. The resulting technologies will provide ultra-low emissions along with improved vehicle handling and interfaces with intelligent transportation systems (ITS). FTA will encourage further adaptation of electrical hybrid technologies developed by the DUETS program for wide application in electric and hybrid electric vehicles for meeting Clean Air Act and Americans With Disabilities Act requirements.

Advanced Bus Propulsion Systems (FTA)

FY	1997	1998	1999
Funding	9,500	8,000	NA
FTE	NA	NA	NA

This program's goals are fourfold: develop and demonstrate a low- and zero-emission propulsion system for transit vehicles with lower operating and maintenance costs; foster introduction and commercialization of low- and zero-emission transit vehicles; complement efforts under the PNGV program for automobiles; and enhance the vitality, competitiveness,

and responsiveness of U.S. industry in the fuel cell, electric, and hybrid-electric propulsion market. Work includes:

- Completing the development of fuel cell propulsion systems for transit buses. Fuel cells promise highly efficient and environmentally acceptable propulsion, with twice the operating efficiency of a typical diesel engine, with negligible emissions, and none of the range limitations of battery-powered buses. Both the phosphoric acid fuel cell and the proton exchange membrane fuel cell technologies are being developed for bus propulsion systems. This will include demonstrating a fuel cell on the ATTB. Partnering with FTA in this multi-year program are the Defense Advanced Research Projects Agency (DARPA) and the Department of Energy.
- Continued research into safe handling of fuel for fuel cells and for technical support to augment the capabilities of the FTA staff to conduct engineering analysis and evaluation of emerging bus propulsion technologies. FTA will continue to collaborate with DARPA, the Department of Energy, the Environmental Protection Agency and the Department of Interior (National Park Service) for near-term applications.
- Accelerated demonstration of more efficient hybrid-electric and all electric transit vehicle technologies, which will become the next stage of improvement from diesel buses currently in operation.

Related Departmental Activities

Servicewide Safety and Environmental Compliance (USCG)

To facilitate compliance with safety and environmental laws, USCG conducts a range of research efforts in the areas of vessel safety, pollution prevention, aviation engineering support, and vessel loss exposure and risk analysis. Current activities with the potential applicability to other surface modes include: development and laboratory testing of a fuel cell propulsion module to determine engineering, safety, and economic characteristics; and development in conjunction with EPA of portable methods to measure ship air pollution; assessment of current USCG cutter emissions.

Support for Interagency Ship Structure Committee (USCG)

As discussed above, the Ship Structure Committee (SSC) coordinates interagency efforts by sponsoring research projects of mutual interest that apply advanced technology to the maintenance, repair, and economical construction of ships. USCG support of these efforts focuses on advanced composites, rupture resistant cargo ship designs, failure definition for assessing structural reliability, and in-service nondestructive methods for assessing fatigue and fracture properties of ship structures.

CHAPTER 5

HUMAN-CENTERED TRANSPORTATION SYSTEMS

Acting as operators, crew members, or passengers, people are essential components of all transportation systems. Their capabilities, decisions, and performance significantly affect the transportation system's overall safety and efficiency. Likewise, there is no doubt that reducing or mitigating human errors could improve safety: Approximately 60 to 80 percent of all transportation accidents involve some form of human error.

Today, transportation is undergoing a revolution. We are developing, introducing, and adopting many new technologies, largely based on advanced information and computer systems, to assist transportation operators in making critical decisions. If properly employed, these technologies can dramatically improve transportation safety, reliability, and productivity. However, these gains will in large part depend on properly incorporating the human as a central element in the new systems.

As they are applied to transportation, advanced technologies often do not achieve their full potential because of a failure to consider fully the human factors involved in technology use. If we are to realize significant improvements in safety and efficiency, it is imperative that we design, employ, and operate new technologies from a "human-centered" perspective. Human-centered approaches recognize that technology can be only as good as the humans that operate it. The success of human-centered technology comes from putting people first and recognizing that the human contribution is a critical part of technology development and implementation.

The NSTC Committee on Transportation R&D has identified three components of human-centered technology:

- *Human-centered interfaces — Focusing design, product, and systems development to fully anticipate, take advantage of, and effectively use human capabilities.*
- *Human-centered operations — Focusing on ways to make operation of systems more effective and safe through improvements in procedures, training, and selection.*
- *Human-centered systems integration — Focusing systems design, construction, and implementation to include fully the human user in the assessment of safety, security, environmental risk, comfort, efficiency, economics, and choice.*

By contributing to safety and productivity, R&D in the area of human-centered technology supports National goals for economic growth, competitiveness, and job creation. Because human performance R&D often lacks private support, and because human performance is crucial to the safety of the transportation system, Federal investment and leadership is

required. The objective of Federal efforts supporting the development of human-centered transportation systems is to ensure that needed data and methods are available to U.S. industries that design and produce advanced transportation technologies. The following surface transportation programs have human-centered concerns as their primary focus. Related near-term programs are discussed in the next section.

Near-Term Efforts

Commercial Vehicle Operator Human Factors (FHWA)¹⁵

The objective of this program area of the FHWA Office of Motor Carriers (OMC) is to ensure that commercial motor vehicle (CMV) drivers are physically qualified, have the knowledge and skills necessary to operate safely, are appropriately licensed, and are alert and unimpaired behind the wheel. The program embraces a broad range of topics, including CMV driver medical qualifications, loss-of-alertness/fatigue, substance abuse, and driver training.

Research results may form the technical foundations for changes to DOT's Federal Motor Carrier Safety Regulations, which primarily govern trucks and buses in interstate commerce. Accordingly, the topics for research are highly applied. The experimental designs provide representative models of real-world motor carrier operations. Near-term research activities include the following:

- **Human Factors** - New logistical realities such as just-in-time delivery and "zero" inventories, tagging and tracking, and communications, require the commercial driver to shoulder increased responsibilities for the efficient and timely movement of commodities. Consequently, human factors research has been, and will continue to be a top priority for OMC's research program.
- **Technology** - This includes research to develop and apply technology to monitoring driver activities in-vehicle, promoting the safe operation and maintenance of CMV components and systems, improving cargo securement, safe accommodation of multi-trailer combination vehicles, and safe transportation of hazardous materials.
- **Information Analysis** - The OMC *Analytic Strategic Plan* resulted in a number of recommendations to increase the role of analysis in planning. Models are being developed to measure the effectiveness of the OMC's major safety programs, and data collection for and testing of those models is currently underway.

¹⁵Funding for this program is included in the Motor Carrier Research program, discussed in Chapter 4.

- **Regulatory Reform** - The zero-base review of the Federal Motor Carrier Safety Regulations (FMCSR) was designed to examine all facts of commercial motor vehicle safety as though no regulations existed, through a comprehensive multiyear effort. The objectives are to improve CV safety, eliminate unnecessary burdens, improve the enforceability of existing regulations, make the regulations more understandable, and provide for the adoption of performance-based guidelines.
- **Service and Partnerships** - This includes cooperative research activities that aid State and local improvements to vehicle safety, inspection, and maintenance. The "no-zone" initiative, an effort to publicize the need for safe vehicle operation around commercial motor vehicles, is a current priority.

FY 1998 milestones will include:

- Dissemination of information about the impact of fatigue on drivers engaged in loading and unloading of vehicles, driving in local/shorthaul operations, and using sleeper berths.
- Identification of diagnostics that can effectively warn commercial drivers of faulty systems (e.g., brakes), verify vehicle emissions, determine the compliance status of the motor carrier, and offer an assessment of the factors contributing to CMV accidents.
- Development of a multi-disciplinary crash investigation course.

Highway Safety Research (NHTSA)

FY	1997	1998	1999
Funding	5,123	5,123	NA
FTE	17.15	18.15	NA

NHTSA's Highway Safety Research Program is designed to change the knowledge, attitudes, and behavior of drivers, passengers, pedestrians, bicyclists, and others who share the road. Results of the program are directed at both roadway users and at organizations, such as law enforcement agencies, the judiciary, and the senior citizen and health care communities, which are in a position to influence roadway users. The program has eight major components, with the largest effort aimed at reducing the effect of driver alcohol and drug use — clearly the principal cause of driver performance failure and a high priority for NHTSA. Key initiatives and ongoing research in each of the components include:

- **Alcohol and Drugs** — Determine the feasibility of expanded breath testing programs, assess use of advanced communications technologies to detect suspended drivers, develop prototype countermeasure programs for high-risk target groups, and improve police DWI patrol procedures and methods for detecting alcohol- and drug-impaired drivers.

- Occupant Protection Use — Develop better data on the causes for low usage rates in youth, rural residents, and minority groups. Develop strategies to improve levels of seat belt law enforcement. Conduct a biennial National survey on occupant protection issues. Determine crash consequences of common forms of child safety seat misuse.
- Older Driver Research — Identify ranges of common impairments and determine methods for measuring and modeling performance of drivers with various levels of impairment. Develop guidelines for police, licensing agencies, physicians and allied health professionals, and friends and family members to assist older drivers in making appropriate decisions about driving.
- Pedestrian and Bicycle Safety — Develop cost-effective countermeasures for states and localities. Assess public attitudes and awareness of pedestrian and bicyclist safety problems. Evaluate pedestrian safety zone approaches in reducing crashes involving older pedestrians. Develop safety countermeasures for specific types of bicyclist/motor vehicle crashes. Examine the involvement of various populations in alcohol-related pedestrian crashes.
- Speed and Unsafe Driving — Complete 1) a crash investigation study to determine when, where, and under what conditions speeding leads to crashes; and 2) a nationwide driver survey on why drivers speed and engage in other unsafe driving behaviors, including the conditions under which such behaviors occur. Develop enforcement strategies.
- Driver Education — Adapt curriculum materials to fit two-phased instruction coordinated with states' provisional or graduated license systems. Develop support training modules, including the use of parents and other adults in improving driving practice and decision-making skills and the use of electronic simulators to improve the teaching of safe driving.
- Driver Fatigue and Inattention — Collect and analyze information regarding the role of fatigue and inattention in crashes. Develop and test technological, informational, and educational countermeasures to reduce the incidence of these factors.
- Evaluation — Document and assess implementation processes and evaluate existing and new countermeasure programs to determine their impact and suitability for widespread adoption. Evaluate occupant protection demonstration grants, alcohol-impaired driving countermeasures, the Safe Communities Program, and various other innovative state and local programs.
- Emergency Medical Services (EMS) — Render technical assistance and support for the development of organized systems of emergency medical care. Provide the technical foundation and support to facilitate further research among the broad EMS community.

- **Social Marketing** — Identifying sub-groups of the population that are most in need of intervention, devising approaches that will be effective with those sub-groups, and choosing delivery mechanisms that will effectively reach them.
- **Injury Control** — Identify traffic injury patterns, design interventions to address the identified causes, and field test the resulting programs to determine the extent to which they reduce the number of injuries.

A major milestone for FY 1998 is to determine the crash risk for various blood-alcohol levels.

Human Factors Research (FRA)

FY	1997	1998	1999
Funding	2,000 ¹⁶	2,000 ¹⁷	NA
FTE	2	2	NA

This FRA research program is designed to improve railroad industry safety and productivity through an improved understanding of human performance, and through the development, characterization, and demonstration of technologies and practices that fully support system operators. Current activities include the completion of the evaluation of test designs for dispatcher workload, stress, and fatigue; reporting on optimal acoustic warning system research; and reporting on dispatcher training practices. A major FY 1998 milestone will be the publication of advanced ergonomic design concepts for operator displays for new generation locomotive cabs and dispatcher control centers.

Maritime Safety (MARAD)

FY	1997	1998	1999
Funding	0	0	NA
FTE	NA	NA	NA

MARAD's program focuses on a human-centered approach to the practical application of behavioral science principles to implementation of people improvements in transportation maritime systems. Improvements are necessary because of the high probability of human error, the extreme competitiveness in international trade, the rapid introduction of automation advances combined with great pressures for low manning levels, and the significant safety and environmental impacts of maritime accidents. Research initiatives are accomplished largely

¹⁶Included in funding for FRA *Equipment, Operations, and Hazmat* research (\$5,545k in FY 1997).

¹⁷Included in funding for FRA *Equipment, Operations, and Hazmat* research (\$5,509k in FY 1998).

through industry-government cooperatives involving industry leadership. Near term cooperative research initiatives include:

- **Human Factors Cooperative Research Program** with the Federal and the six State Maritime Academies. The program consists of shared research efforts to apply human factors knowledge and advanced technologies to improve safety and performance of maritime transportation. Projects benefiting the entire industry are identified and their execution shared by the cooperative members. Projects range from developing a bibliographic data base of maritime human factors resources for the World Wide Web to reforming the education of cadets to include human factors elements such as bridge resource management concepts to developing a consensus view of the maritime transportation system in the twenty first century.
- **Vessel Piloting Cooperative Program** with the American Pilots Association (APA) with its more than 50 member associations. The program works through the APA Navigation and Technology Committee and develops efforts that seek to apply advanced technologies to provide practical improvements to the safety of piloting operations in U.S. waterways. Focus is on human factors aspects and ship-pilot interactions and the use of advanced electronics and technology.

One FY 1998 milestone for the Vessel Piloting Cooperative is to complete test and evaluation of portable navigation technologies by pilot associations through the Piloting Cooperative and report results to the industry through workshops or symposia.

Safety and Security (FTA)

FY	1997	1998	1999
Funding	650	1,100	NA
FTE	NA	NA	NA

The performance of transit operators is a key determinant of the personal safety of transit passengers, and of the ability to deter security threats to transit passengers, vehicles, and facilities. The goals of FTA's Safety and Security work are to improve personal security and operational safety, to develop and demonstrate new and innovative security and safety technologies, and to improve emergency management planning. These goals are accomplished primarily through a program of technical assistance workshops, training, and regulatory support. Ongoing research projects include the following:

- **Regulatory Support** — Provide assistance to grantees and states in implementing Federal requirements for drug and alcohol testing of safety-sensitive employees and for state safety oversight of fixed rail systems through the dissemination of training materials and technical guidance.

- **Industry Support** — Provide training for approximately 6,000 students annually through the Transportation Safety Institute on subjects that include system safety, accident prevention and investigation, system security, emergency management, and alternative fuels handling. Collect, analyze, and publish safety and security data. Provide outreach to transit authorities through a National clearinghouse and bulletin board on safety and security matters.
- **Security** — Provide technical assistance to transit systems seeking to replace traditional security strategies with more proactive, creative approaches. Conduct security audits to support enhancement of transit security operations.

An important milestone for FY 1998 is to implement a process for auditing grantees' drug and alcohol testing programs.

Related Departmental Activities

Aviation Human Factors (FAA)

FAA human factors programs are responsive to the *National Plan for Civil Aviation Human Factors*. This plan, jointly developed by the aviation industry, academia, NASA, DOD, and the FAA, establishes a behavioral research agenda and strategies to enhance the safety and efficiency of the aviation system. The FAA core research program includes:

- **Human-Centered Automation** — Establishment of human interface design principles and criteria for automated and advanced systems.
- **Selection and Training** — Establishment of criteria and techniques for efficiently acquiring and training aviation personnel.
- **Human Performance Assessment** — Establishment and utilization of measures to assess individual, crew, and organizational human performance in aviation systems.
- **Information Management and Display** — Establishment of critical human performance parameters required to effectively transfer information in the aviation system.
- **Bioaeronautics** — The bioengineering, biomedicine, and biochemistry associated with performance and safety.

Marine Safety (USCG)

This Coast Guard program addresses a variety of issues concerning professional and nonprofessional operators with a wide range of skills, from highly trained ship masters to

barge operators, fishing boat crew, and recreational boaters. Human factors data on operation of oceangoing vessels is shared with the Maritime Administration. Near-term research priorities include:

- Developing methods to improve crew alertness on towing vessels.
- Developing risk-based resource allocation methods.
- Improving the understanding of the causes of human error through data collection and incident analysis.

CHAPTER 6

INTERMODAL SYSTEMS ASSESSMENT, DESIGN, PLANNING, MANAGEMENT, AND OPERATIONS

System assessment capabilities need to be applied across the wide range of activities and externalities associated with the entire transportation enterprise; covering both the system as a whole as well as its individual elements. This need is evident in the research, investment, operational and policy decisions made by both public agencies and the private sector. In many cases, the results of a single system assessment activity -- whether it be data and information or analytical judgments -- can support a wide range of transportation decisions. In general, however, it is possible to sort the application of transportation system assessment capabilities in the Federal government into two broad categories: support for infrastructure planning, design, management and operations; and support for public policy decision making.

Infrastructure Planning, Design, Management and Operations

Perhaps the most clear-cut role for system assessment lies in the planning and design of transportation infrastructure construction and rehabilitation activities, and in managing existing facilities. Without credible quantitative measures of current performance, the degree of need for improvements in one area cannot be judged or compared to other uses of the same resources. The multi-dimensional costs and benefits -- covering economic, safety, environmental, energy, and mobility and access issues -- of alternative courses of actions, including the decision to "do nothing", can only be known if the data, analytical tools, performance measures, and other elements of system assessment are available.

Similar issues arise in evaluating choices among operational strategies and practices. For example, better understanding of flows on networks, and the underlying transportation needs that shape them, can facilitate improved system management and operations and better maintenance, fleet assignment, and vehicle replacement decisions. This is equally true for a public sector transit agency or for a private sector airline or trucking company. Broad system assessment knowledge is even more important in responding to complex topics such as tradeoffs between demand management and increased capacity.

At present, widespread gaps exist in our capabilities in this area. Many of the models and data available to address these issues often provide an inadequate foundation for satisfactory resolution. And the current movement toward shifting many transportation infrastructure responsibilities to Metropolitan Planning Organizations (MPOs) and other state and local authorities creates the challenge of assuring that these organizations, which often possess limited resources, have the tools and information necessary to make cost-effective long-term decisions. Thus, there is a need for better infrastructure investment-related models that can be applied by authorities without high level skills and that can cover such topics as life-cycle

costs; the incremental costs associated with attaining accessibility, environmental and other social goals; and intermodal system optimization.

Public Policy Decision Making

Policy and other decision making, including decisions about transportation research and development, require effective data collection and analysis. The absolute and relative values of research in infrastructure materials, vehicle technologies, intelligent transportation systems, and other topics can be judged only on the basis of substantive estimates and comparisons of their impacts on the cost, quality and availability of transportation services and equipment. What would the impacts be of potential innovative transportation technologies, such as a passenger car with 3 times current fuel efficiency? In the transport of hazardous materials, where are the most serious risks for harm and what improvements will have the greatest payoffs? How can new technologies be deployed to benefit transportation? Making the best and most cost-effective transportation investment decisions requires a solid and robust capability for assessment of existing and innovative transportation technologies and their potential impacts. Many DOT programs have associated assessment efforts and BTS serves DOT needs as a policy-neutral focal point for National transportation data.

While outside input is essential, the Federal government can and must take the lead. It is in the best position to coordinate efforts by the transportation community to assess the opportunities and challenges of the future. It can play a key role in developing the necessary knowledge and tools, given the long time-frame associated with transportation investments, the potentially broad impacts of regulatory and policy decisions, and the need for a broad perspective in monitoring social, economic, demographic, and technological trends.

As is discussed in Chapter 6 of Section II, among the most important elements of system assessment are performance measures, data, analytical tools, technology assessments, and awareness of anticipated trends. These are discussed in greater detail in that portion of the report. The Department's plans for R&D in these areas over the next 3 years is presented below.

Near Term Efforts

Policy Research (FHWA)

FY	1997	1998	1999
Funding	5,328	8,000	NA
FTE	6.0	8.0	NA

The objectives of FHWA's policy research program are to provide efficient and timely data collection, management, and dissemination concerning highway transportation; to perform

quantitative analysis of key economic, energy, and financing issues that must be addressed in developing highway policy; and to develop systems and tools to analyze highway system condition, performance, and efficiency.

Policy research is essential for the development of Federal highway policies that are responsive to Federal interests in promoting interstate commerce and improving the competitiveness of domestic products in international markets. Policy research addresses many of the short- and long-term Federal highway policy issues raised in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and will provide analytical tools and data needed to analyze highway program alternatives for the 21st century. Current research efforts include:

- Data Management and Dissemination - To support the needs and expectations of the transportation program, including the NHS, FHWA partners with State and local data collection agencies to address fuels and finances, system performance, traffic monitoring, surveys and censuses, and data dissemination.
- Analysis of Economic, Energy, and Financing Issues - In order to address the unprecedented interest in economic, environmental, energy, and financing issues affecting the highway program, FHWA policy research supports analyses of long-term relationships between highway and intermodal accessibility and the productivity of firms in various industries; development of an improved understanding of the importance of highway transportation to production processes in various industries; and improving analysis methods to explicitly consider external costs and benefits associated with highway investments.
- Productivity and Efficiency of Highway Investments - In order to appropriately weigh investment alternatives, it is important to understand both direct and "external" benefits and costs. The Highway Economic Requirements System (HERS), which supports the biennial report to Congress on the conditions and performance of the Nation's surface transportation system, requires updating to provide greater accuracy under a wider range of conditions and circumstances. Truck size and weight (TS&W) and highway cost allocation research is also included in this area.

Major milestones for fiscal year 1998 will include:

- A test of remote sensing for traffic monitoring will be conducted. Aerial imaging and ground counts will be integrated into an estimate of total area wide travel.
- Guidance to States and MPOs based on evaluation of early innovative financing efforts. This research will summarize and evaluate experiences in implementing innovative financing strategies in different situations as well as examine implementation of new strategies that are being tested.

- Evaluation of the implications of technological and other innovations affecting passenger and freight transportation on future investment requirements. One specific element of this analysis will be to more explicitly include intelligent transportation infrastructure investment in estimating future investment requirements.

Highway Planning Research (FHWA)

FY	1997	1998	1999
Funding	5,889	16,025	NA
FTE	4.0	6.0	NA

FHWA's highway planning research program is designed to develop cost effective methods for State, regional and local governments to evaluate transportation investments and alternatives. Its further goals are to develop and disseminate improved metropolitan and statewide transportation planning methods to enhance the understanding and analysis of land use, intermodal transportation, congestion and environmental interrelationships and to implement planning processes that meet legislative requirements.

Current research priorities include:

- Travel Demand Models - This includes the development and dissemination of improved methods for major investment studies and methods to assess alternative multimodal investment proposals, including social and environmental costs. The *Travel Model Improvement Program* (TMIP), which is conducted jointly with OST, FTA, EPA, and DOE, is a major emphasis in this area. This effort includes the Transportation Analysis and Simulation System (TRANSIMS) program, a major initiative to develop a new generation of transportation models using a microsimulation approach. This is a multiyear project performed by the Los Alamos National Laboratory.
- Congestion Management and Mobility Enhancement - The objective of this research is to develop tools to support MPOs, State DOTs, and local governments in their transportation analysis and investment decisions.
- Finance and Economic Analysis - Increased emphasis is being placed on utilizing innovative ways of financing federal-aid highway projects. Financial analysis tools are needed in order that these innovative financing mechanisms may be considered within the financial segment of the transportation planning process.
- Training, Education, and Technical Assistance - A comprehensive planning research program is being established to close the gap between state-of-the-art and state-of-the-practice in the next five to ten years. Background information and intermodal planning

procedures will be integrated with advanced technologies such as GPS, GIS, and multimedia presentations to promote better multimodal planning.

- ITS Deployment Assessment System - A sketch planning tool is being developed to assist planners in considering ITS alternatives in the course of their analysis of future needs. IDAS is being developed specifically to complement TRANSIMS.
- Alternative Data Collection, Analysis, and Use - Downsizing of government data collection programs, and the formalized requirements for statewide intermodal planning necessitate a major activity to provide data necessary for intermodal planning at all levels of government. This activity will focus on innovative collection methods, effective analysis and presentation techniques, and refinement of intermodal information systems.
- Sustainable Transportation: Land Use and Redevelopment Planning Tools, Cases, and Pilots - This new initiative will address an array of issues, as broad as metropolitan areas contribution to global climate change, and as specific as the benefits of restoring and redeveloping contaminated areas for infill development. Over a multi-year period, FHWA will develop analytical tools to support MPOs, State DOTs, and local governments in their transportation analysis and economic development decisions from the standpoint of their land use and environmental impacts. FHWA will help fund pilot projects to demonstrate the effectiveness of these tools and to determine alternative strategies for fostering sustainable transportation and development, including reinvestment in abandoned or underutilized industrial and commercial areas in the urban core.

Major milestones in FY 1998 will include:

- Identification of freight, vehicle, and person forecasting procedures in use by the States.
- Case studies of State DOT and MPO application of methods for identifying and relieving congestion.
- A report addressing how States and MPOs integrate multimodal transportation investments and economic development analysis in transportation planning processes.
- Technology transfer on forecasting procedures for vehicles, persons, and freight.
- Demonstration of the application of advanced technology for intermodal data collection.
- Identification and assessment of effective methods of collaboration of planning efforts traditionally conducted at different jurisdictional levels (e.g., State, metropolitan, county, city, or town).

*National Advanced Driving Simulator
(NHTSA/FHWA)*

FY	1997	1998	1999
Funding	14,000 ¹⁸	12,250 ¹⁹	NA
FTE	NA	NA	NA

In February 1996, the National Highway Traffic Safety Administration (NHTSA) announced the award of a \$34.1 million contract to TRW's Transportation System Division in Sunnyvale, Calif., for the development, testing and installation of the National Advanced Driving Simulator (NADS). This simulator will offer a major advance in helping researchers to understand the human factors involved in traffic crashes, in order that their frequency can be reduced.

The NADS will be the world's most technically sophisticated research driving simulator, capable of providing test drivers with an experience that nearly duplicates real world driving. The facility will be located at the University of Iowa in Iowa City at the Oakdale Research Park. The University of Iowa was selected for the NADS site based on the recommendations of the National Science Foundation, which helped NHTSA to conduct a National competition among major transportation research universities for the potential site for the NADS. The construction of the simulator will be completed in 39 months and it will become operational in spring 1999, under the NHTSA's stewardship.

The University of Iowa has agreed to provide cost sharing to the NADS project in the amount of \$11.58 million. This will include the design and construction of a \$5.7 million building, which will be a facility dedicated to housing the simulator operation.

The NADS will primarily be used to conduct fundamental research in traffic safety, integrated vehicle safety systems, and advanced vehicle design. The NADS could also be used for human factors research, since it will be able to put drivers in realistic problem situations such as the sudden appearance of a child in the road, a skid on glare ice or an oncoming vehicle driving over the centerline. Imminent crashes can be simulated without the unwanted and unsafe consequences of crashes on the highway. The study of driver reactions can lead to potential improvements in vehicles, highway and vehicle design, and advanced safety systems.

¹⁸Funding through FHWA/ITS from ISTEA Section 6058.

¹⁹Funding through FHWA.

Current NADS priorities are to:

- Complete the detailed design and design review of all subsystems.
- Initiate fabrication, installation, and test of the facility.

An important milestone for FY 1998 will be to complete facility building construction.

Fatal Analysis Reporting System (NHTSA)

FY	1997	1998	1999
Funding	5,242	5,242	NA
FTE	6.40	6.41	NA

The FARS annually compiles detailed information regarding the drivers, occupants, vehicles and environmental conditions associated with all fatal motor vehicle crashes occurring in all 50 states, the District of Columbia, and Puerto Rico. Maintenance of this data base is based on 52 cooperative agreements between DOT and the governments of these jurisdictions, which cover the collection and coding of data on fatal motor vehicle incidents. Among the data categories included in FARS are: demographic data and alcohol levels of fatalities, use of safety belts and child restraint devices, types of vehicles and their crash-related movement ("first harmful event"), types of road and roadway surface conditions, time of day, light and atmospheric conditions, and emergency medical services response times.

FARS is a key database for the study of fatal crashes and their causes, as well as the development and implementation of possible measures to ameliorate the number of such incidents and their severity. Users include researchers, analysts and policy makers from Federal, state and local government, universities and other research organizations, private interest groups and the transportation industry. A key fiscal year 1998 milestone will be the completion of the first year of a second five-year cooperative agreement with the 50 states, Washington D.C., and Puerto Rico.

National Automotive Sampling System (NHTSA)

FY	1997	1998	1999
Funding	9,658	9,658	NA
FTE	10.67	10.68	NA

The NASS is an extensive, nationwide data collection system managed by NHTSA's National Center for Statistics and Analysis, which compiles information on both fatal and nonfatal motor vehicle crashes. The NASS has two components: the General Estimating System (GES) and the Crashworthiness Data System (CDS). In the GES, data collectors regularly

visit several hundred law enforcement agencies and select a random sample of approximately 52,000 Police Accident Reports (PARs) from among the more than 6 million such reports filed annually in the United States. The CDS contains crashworthiness-related data from detailed investigations of approximately 5,500 passenger vehicle crashes annually.

Information from these samples is entered into the NASS databases and is made available to Government agencies, researchers, transportation businesses, insurance companies, and the general public. These NASS resources are used extensively to identify and analyze trends in motor vehicle crashes, to discern highway safety problem areas, to support highway safety rulemaking and research (such as ITS), and to form the basis for cost and benefit analyses of potential highway safety initiatives. A major milestone for fiscal year 1998 will be the collection and coding of NASS data in 26 states.

Data Analysis Program (NHTSA)

FY	1997	1998	1999
Funding	1,635	1,935	NA
FTE	13.88	12.82	NA

The NHTSA Data Analysis Program supports the agency's achievement of its Government Performance and Results Act of 1993 (GPRA) performance goals by providing sampling, statistical design, and quality control support to NHTSA's major data collection systems, including the FARS, CDS, and GES. These services are provided to both internal (NHTSA) and external (other Federal agencies, nongovernmental) customers of these important highway safety data systems. This program also produces regular statistical reports on highway safety and motor vehicle crashes.

Among the uses of the data made available through this program are evaluations of the effectiveness of NHTSA's crashworthiness, crash avoidance, and traffic safety efforts, as well as relating human, vehicle, roadway, and environmental factors to the frequency of crashes and injuries. A key milestone for fiscal year 1998 will be the identification of injury mechanisms and associated outcomes in motor vehicle crashes.

State Data Program (NHTSA)

FY	1997	1998	1999
Funding	3,041	3,041	NA
FTE	9.61	9.61	NA

In addition to NHTSA, individual states also manage highway safety databases, compile statistics, and prepare reports on highway safety and crashes. NHTSA's State Data Program is the major interface between the agency and these state level data systems. The Program

obtains highway safety data files for NHTSA from 17 different states, assists states in making improvements to state data collection efforts and data systems, and promotes the development of linked databases that combine information from motor vehicle crashes and the medical outcome of treatment for crash victims. This latter function is particularly important to meeting NHTSA's health care initiatives.

Among the program's near-term goals are promoting the increased use of linked crash and medical outcome databases by states. The results of this effort can be then used by the states to develop and evaluate initiatives to prevent injuries from traffic crashes and enhance health care for crash victims. Major milestones for the 1998 fiscal year will be obtaining, documenting, and making available for use the data files from 17 states and awarding cooperative agreements to up to two additional states to link and use their crash and medical outcome databases.

Occupant Protection Survey (NHTSA)

FY	1997	1998	1999
Funding	300	300	NA
FTE	1.00	1.00	NA

The goal of the Occupant Protection Survey program is to support NHTSA's efforts to promote the increased use of safety belts, child safety restraints, and motorcycle helmets by the general public. This was accomplished by a second National Occupant Restraint Use Survey, which was conducted in FY 1997. Periodic surveys of safety belt and child safety seat use and misuse are critical needs of our safety belt use program. A major milestone for fiscal year 1998 will be the analysis and publication of results comparing the FY 1994/1995 and the FY 1996/1997 National Occupant Protection Use Surveys.

Special Crash Investigations (NHTSA)

FY	1997	1998	1999
Funding	331	1,031	NA
FTE	1.07	1.07	NA

NHTSA's major data activities -- such as FARS, NASS, and the Data Analysis Program -- cover the vast majority of highway safety and vehicle crash circumstances. However, there are specific safety-related topics which require a more focused and detailed approach. The Special Crash Investigations program tackles these problems. It is the agency's primary resource for studying the safety issues associated with new technologies, such as air bags and alternative fuels, as well as potential motor vehicle safety defects. In pursuit of this goal, the program conducts approximately 50 detailed crash investigations annually covering such diverse issues as school bus crashworthiness and fatalities, potential vehicle safety defects, the

performance of automatic restraint systems, and electric vehicles. A major milestone in fiscal year 1998 will be the creation of an electronic file of all special crash investigations.

Technology Transfer Programs (NHTSA)

FY	1997	1998	1999
Funding	40	40	NA
FTE	1	1	NA

The goal for this program is to provide more timely information about NHTSA's safety research and development results, contracts, and reports to the interested motor vehicle and traffic safety community by periodically publishing and distributing a technical journal, *Auto & Traffic Safety*. It contributes to the larger goal of a healthy, educated citizenry. The major fiscal year 1998 milestone will be the production of two additional issues of this journal.

National Security (MARAD)

FY	1997	1998	1999
Funding	0	0	NA
FTE	NA	NA	NA

The fifth goal of the MARAD Strategic Plan is to "provide sealift for National security and the National defense." The American maritime industry is a vital component of our Nation's defense, both in providing strategic sealift and in supporting the shipbuilding and repair industrial base. MARAD is a partner with the industry and the Department of Defense, (especially the U.S. Transportation Command) in ensuring that this goal is met. New R&D initiatives in this area for fiscal year 1998 include:

- Initiation of projects to assist in the administration of the Maritime Security Program (MSP) and related functions to ensure the availability of a modern, efficient merchant marine to support National security objectives.
- Initiation of analysis of various sealift planning strategies under different mobilization scenarios taking into account factors such as manning requirements and availability, increased use of containerization and other commercially adaptable cargo handling practices by the military, geographic effects on trade, multiple theatre conflicts, and varying lift requirement levels.

Transit Services and Management Innovation (FTA)

FY	1997	1998	1999
Funding	1,500	700	NA
FTE	NA	NA	NA

The goals of the Transit Services and Management Innovation Program are to enhance transit services to improve the quality of life for all Americans through research, demonstrations, technical assistance, and evaluation of innovative transportation methods and services that enhance mobility, access, transit operations and management, and intermodal services. This includes deployment of innovations in fare policies, structures and fare collection methods and techniques such as bus route evaluation standards, customer satisfaction index, passenger transfer policies and application of GIS databases. The request also involves project case studies, formal project evaluations, and technical information dissemination to facilitate technology transfer and encourage widespread adoption of successfully demonstrated service and management innovations, including updating current technical information for the FTA Internet Home Page, publishing and distributing technical reports and abstracts, and conducting workshops and seminars.

Rural and Specialized Transportation (FTA)

FY	1997	1998	1999
Funding	2,500	2,500	NA
FTE	NA	NA	NA

Through the Rural and Specialized Transportation Program, FTA will bring together the Administration's various rural and specialized research and technical assistance efforts in order to provide adequate assistance to develop innovative and creative solutions to many problems that impact the rural and specialized transportation industry. Major current activities include the following:

- Service experimentation, technical assistance, and governmental resource coordination, as well as advanced technologies in customer information, dispatching systems, and automatic fare collection. Special emphasis will be placed on service innovations for citizens impacted by welfare reform and residents of rural areas.
- Formulating vehicle maintenance research for specialized accessible equipment as it impacts the Americans with Disabilities Act.
- Developing research and technical assistance for the development of universal securement systems for rural and specialized transit systems.

Major FY 1998 milestones will include:

- Technical assistance to enhance mobility for the disabled, and low income transportation passengers in rural areas.
- Innovative transportation strategies for services provided by the Departments of Health and Human Services, Education, Agriculture, and Labor.
- Team Transit demonstration project in Minneapolis, technical support for the autonomous dial-a-ride transit system under development in Corpus Christi, Texas and the Independent Transportation Network (ITN) demonstration for elderly transit customers in Maine.

Metropolitan/Rural Policy Development (FTA)

FY	1997	1998	1999
Funding	300	1,000	NA
FTE	NA	NA	NA

The goals of FTA's Metropolitan/Rural Policy Development research are to develop better estimates of transit's condition, performance and long-term investment needs; identify and evaluate the benefits of transit; conduct research into the relationships between transit and land use planning; provide technical assistance to encourage the use of and develop new innovative financing techniques; support the State Infrastructure Bank pilot program; and conduct outreach on transit's contribution to the future of cities and neighborhoods. This includes the refinement of national data on transit's role and performance in serving needs of passengers and communities, including transit's role in providing basic mobility, relieving traffic congestion, and contributing to community vitality.

Transportation Planning and Project Development Research (FTA)

FY	1997	1998	1999
Funding	700	1,200	NA
FTE	NA	NA	NA

FTA funds research in support of the metropolitan and statewide transportation planning and project development process. Activities carried out under the Planning and Project Development program ultimately assist state and local transportation planners in implementing the multimodal planning requirements contained in ISTEA. The major objective of these activities is to develop a better understanding of social, environmental, and economic phenomena related to transportation investments in order to develop and encourage the use of better evaluative tools and processes for transportation planning and priority setting.

Human Resources (FTA)

FY	1997	1998	1999
Funding	150	500	NA
FTE	NA	NA	NA

FTA's activities related to Human Resources are intended to encourage increased minority and female employment in the transit industry and methods and techniques to train and maintain qualified transit operations personnel, including: providing training for grantees to enable them to successfully implement their diversity programs; providing courses in minority high schools and colleges/universities to prepare students for careers in transit; and developing methods and techniques to train unemployed persons and underemployed employees for entry-level employment and higher-level employment. These resources will bolster efforts to promote careers in transit to assure a pipeline of qualified educated persons entering the transit industry. The request will also provide support for meeting Federal requirements, including: conducting an outreach program for disadvantaged businesses to advise them of special initiatives that offer significant contracting opportunities; conducting training for ADA compliance reviews and complaint investigations to ensure full compliance; and incorporating environmental justice requirements, which safeguard minority communities against adverse environmental and safety impacts, into on-going civil rights compliance reviews.

National Transit Institute (FTA)

FY	1997	1998	1999
Funding	3,000	3,000	NA
FTE	NA	NA	NA

The NTI, located at and managed by Rutgers University, assists the transit industry in the training and development of its workforce by developing and conducting training in support of the transit industry, mostly in the field. The NTI plays a key role in FTA's efforts to build professional capacity in the transit industry, particularly as it relates to the introduction and deployment of new technology and related support systems. FTA, the NTI and the transit industry have formed a partnership around the need to train and develop transit professionals at a time when resources are shrinking and demands for greater efficiencies in performance and productivity are rising.

Curriculum has been developed to train transit operators in how to implement and meet Federal regulations, standards and policy initiatives, such as the ADA and Clean Air Act Amendments. In addition, courses are available that provide hands-on experience in new technological methods and techniques. Subjects such as geographic information systems (GIS) and automatic vehicle monitoring are just a small sample of offerings underway. NTI will continue to promote best practices in training and make available subject matter experts at conferences and workshops.

Rural Transit Assistance Program (FTA)

FY	1997	1998	1999
Funding	4,500	4,964	NA
FTE	NA	NA	NA

The Rural Transit Assistance Program (RTAP) provides training and technical assistance for rural public transportation operators, improves professionalism and safety of rural transit services, and supports coordination with human service transportation providers. Major activities include training for drivers, mechanics, and rural public transportation managers; support for implementation of drug and alcohol testing requirements; and technical assistance needed by rural transit and human service transportation providers. Major fiscal year 1998 milestones will include

- Provision of training and technical assistance to rural transit operators in each state.
- Increased use of information and communications technology to support transfer of best practices.

Research and Technology (RSPA)

FY	1997	1998	1999
Funding	6,580	5,296	NA
FTE	NA	NA	NA

The goal of RSPA's Research and Technology (R&T) program is to provide departmental leadership for national transportation research by advancing U.S. transportation technology and the U.S. transportation enterprise; by providing the Department with the technical and analytical base to ensure that R&D planning decisions are technically and strategically sound; and to apply technological advances to improve U.S. transportation system mobility, safety, security, and efficiency.

Current RSPA R&T activities include:

- Completing a Government-wide *Transportation Science and Technology* document.
- Holding 3-5 national roundtables on R&D strategies and performance measures.
- Conducting strategic planning for transportation research, culminating in the annual development of the Department's *Surface Transportation Research and Development Plan*.

- Conducting analysis and developing working papers supporting the Department's participation in the interagency National Science and Technology Council (NSTC) and DOT's internal R&T Coordinating Council and Steering Committee.
- Conducting a program-level evaluation of the effectiveness of the University Research Institutes (URI) program.
- Investigation of the potential for robotics for maintaining transportation structures, and of the potential for application of biomechanical and nanotechnology systems in transportation.

Key FY 1998 milestones will include:

- Second editions of departmental Transportation Technology and Intermodal/Multimodal strategic research plans.
- An operational departmentwide R&D project tracking system.
- An expanded National Agenda for Human Factors Related Transportation Safety Research.

Related Departmental Activities

Transportation Policy and Planning Research (OST)

The OST Policy office conducts research activities and studies concerned with planning, analysis, and information development needed to support the Secretary's responsibilities in the formulation of national transportation policies. These responsibilities include: developing and coordinating environmental, energy, and safety policy; developing and implementing transportation economic policy; formulating and providing overall transportation radionavigation and positioning policy; and developing and coordinating aviation and international policy. Specific near-term research efforts in these areas include:

- Developing recommendations for improving transportation in a maturing society.
- Determining the feasibility and cost of applying the ADA to the marine passenger vessel fleet and related shoreside facilities.

- Providing overall management for the Travel Model Improvement Program (TMIP) and coordinating the various projects funded by the sponsoring agencies (FHWA, FTA, EPA, DOE, and OST).
- Synthesizing the best analyses performed to date on U.S. economic and trade trends and assessing their implications for future freight transportation requirements and federal programs and research priorities.
- Preparing the next edition of the *Federal Radionavigation Plan (FRP)*.
- Strategic planning for long-term satellite navigation technology.
- Providing technical support to the Positioning/Navigation Executive Committee and Working Group.
- Interaction with civil users of GPS and other federally-provided radionavigation systems.
- Continuing analysis of the effects in the U.S. and Mexico of the removal of legal barriers to truck and bus operations in each country.

Bureau of Transportation Statistics (BTS)

BTS was created by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), partly in response to the perception that the data available to support transportation policy making and decisions were not sufficient for that purpose. BTS fulfills several important functions:

- Compiling, analyzing, and publishing a comprehensive series of transportation-related statistics.
- Coordinating data collection across the Federal government and identifying both short-term and long-term data collection needs.
- Issuing guidelines for the accurate and reliable collection of the information.
- Making the data readily accessible.

The mission of BTS is the establishment and maintenance of a comprehensive information infrastructure for transportation statistics and analysis from the perspective of users and markets, rather than specific transportation modes. Key customers are national, state, and local governments; transportation-related associations and the broader transportation community; private business and industry; and consumers. The goal of BTS is to provide transportation-related information to decision makers to enable them to make good decisions in

a timely manner, and with the right data. These decisions focus most importantly on transportation infrastructure investment, policies and planning, as well as on economic policy, safety, national defense, and national welfare.

BTS is committed to providing quality customer service and actively reaching out to and supporting the Department, the transportation community, and the public. BTS is responding to this challenge with the following efforts:

- First, the Bureau produces and distributes several data compilations, including the National Transportation Statistics and the 1990 Census Transportation Planning Package (CTPP) data tabulations in statewide and urban packages.
- Second, the Bureau is actively engaged in three major multimodal surveys on domestic freight movements, passenger movements, and transborder freight flows.
- Third, the Bureau prepares a number of analytical studies to address and help facilitate the national dialog about important issues such as the contribution of transportation infrastructure to economic growth, international competitiveness, and environmental quality. The centerpiece is BTS's Transportation Statistics Annual Report, which summarizes the state of the U.S. transportation system, the quality of the available statistics, and planned efforts to improve these statistics.
- Fourth, the Bureau has established a Geographic Information System (GIS) Center to provide data integration, display service, and analysis.
- Fifth, the Bureau provides public access to data and reports through a wide spectrum of channels and is developing new technologies to provide electronic library and archival services. Services include Internet, a toll-free statistical information hotline, and fax-on-demand.

Near-term BTS goals include the following:

- Integrating data on transportation from a variety of surveys (including Commodity Flow, American Travel, Rail Waybill, Waterborne Commerce, Air Passenger, and Domestic Transportation of Foreign Trade Surveys).
- Developing national performance measures and supporting interpretive material to answer the basic questions: is the system getting better or worse and what do we mean by better or worse. Particular emphasis will be placed on measures that capture the shipper and traveler perspectives.
- Improving tools for unburdensome data collection, data analysis, and information dissemination.

- **Developing, with the Bureau of Economic Analysis, a Transportation Satellite Account.**

A major milestone in fiscal year 1998 will be publication of results from the first American Travel Survey and data collection for the second Commodity Flow Survey.

BTS Interaction with Other Groups

BTS participates in many Departmental and Federal activities. As discussed above, BTS provides information, analytical tools, and other services central to the National Transportation System initiative. BTS is a major partner with other DOT Operating Administrations in the development of new monitoring and forecasting methods for several key aspects of the Travel Model Improvement Program (TMIP). For the Administration's PNGV initiative, BTS is leading DOT's efforts examining infrastructure issues. As DOT's lead agency on the Federal Geographic Data Committee, BTS sponsors projects that directly support the National Spatial Data Infrastructure.

Long-Term Outlook

An effective system assessment capability is essential to assuring that the goals of sustainability, economic vitality and personal mobility and access are fully incorporated into the transportation decision and policy making processes. Expanding research and development efforts in system assessment can help in attaining these goals. For example:

Recent technological advances in fields such as electronics, communications and information systems have magnified the potential benefits of data and information to the transportation community. Electronic Data Interchange (EDI) offers the possibility of real time data collection; computing power and new applications such as spreadsheets and Geographic Information Systems (GIS) enhance the ability to convert that data into valuable information; and the rapidly expanding information infrastructure will completely redefine the nature of making that information accessible.

Further support for the development of programs based on advanced computer and modeling and simulation techniques will enhance BTS's ability to address national transportation-related technical and policy issues.

Effective cost-benefit analyses require as complete and accurate a collection of actual costs and benefits as can be assembled. Currently, data on many of these are either missing or only partially available, especially in such areas as economic benefits and the environmental and human health costs of various transportation activities. Cost-benefit analyses are increasingly important as we face ever decreasing options for expanding capacity through infrastructure investment and transportation demand management strategies.

Research is just beginning on the behavioral responses of transportation users and providers to various transportation policy initiatives. This research is vital because future gains in throughput will likely rely more on economic incentives and other management strategies and less on adding physically to the transportation network.

Our current transportation system is the product of many elements -- including transportation-related institutions, organizations, incentives, policies, and others -- that are continually interacting with each other. There is a need to increase our understanding of this "non-material infrastructure" so stakeholders can interact with each other more effectively in planning and operations.

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CHAPTER 7

DOT INVESTMENT IN UNIVERSITY RESEARCH, EDUCATION, AND COOPERATIVE INITIATIVES

Transportation efficiency and National productivity are inextricably linked. The capacity of the transportation system to enable the Nation to respond to international economic challenges is an increasingly critical factor in transportation research, development, and education. America's future prosperity depends on new ideas and the people who will develop and apply those ideas to ensure the safe and efficient movement of people and goods. In its role as steward of the transportation enterprise, the DOT invests in the ideas and the education of the people who will contribute to the transportation system of the future.

The transportation enterprise is undergoing great change. Technological advance, new trends and approaches to logistics, and institutional change are transforming how the public and private sectors operate.

Technological Advance

The development of new applications and the conversion of defense-related technologies to transportation uses will demand new knowledge, approaches, and education. The application of new information technologies, that are the basis of intelligent transportation systems, promise improved safety and mobility. The successful deployment of ITS requires that transportation research now include investigations of how modern communications, computer and sensor technologies may be integrated into surface transportation.

Innovations in other technologies promise to improve the transportation system. New materials could greatly increase the durability and longevity of infrastructure. Next generation propulsion systems and alternative fuels could revolutionize all modes of transportation. New analytical methods and modeling techniques may improve our understanding and operation of the transportation system. However, if successfully deployed, these technologies and methods will require an educated work force to understand how such technological advances can be successfully integrated into the transportation system and a trained work force to operate and maintain these new systems.

Trends in Transportation Operations and Logistics

Transportation companies and shippers' logistics departments have had to accommodate profound changes in their operating environment. These changes include increased international competition, the technology-driven move to integrated logistics processes, intermodalism, and the increasingly global outlook of major customers. The demand for the efficient, timely, and global movement of goods now dictates the application of technologies

that optimize the use of information and the entire transportation system as one. This approach to goods movement requires that transportation professionals be trained in the use of new information technologies and in the array of technologies available to respond to customer demands on a global scale.

Institutional Change

In addition to advances in technology and business logistics, the transportation enterprise is undergoing institutional change. Transportation policy makers, planners, and operating departments at all levels of government are now increasingly sensitive to the implications of transportation on the natural environment and communities. Resolving transportation issues is no longer only the application of technology or the construction of a new facility--today's transportation professionals must understand the broader context of where transportation fits in a societal, economic, political and institutional framework in order to develop, plan, deploy, and operate effective transportation systems.

Strategic Co-Investment in Universities and Research Institutions

Since World War II, universities and collaborative research partnerships have been the intellectual centerpiece of Federal policy for research, education, and innovation in all policy areas. Federal research and development grants and contracts have been integral to new discoveries, education of new researchers and the training of operators so to provide a steady stream of ideas to improve the Nation's security, health, and industry. DOT invests strategically in and partners with state and local governments, transit properties, universities, and research and training institutions to ensure that the transportation system maintains an adequate knowledge base and a pool of transportation professionals to operate a safe, competitive, and sustainable transportation system.

DOT relies particularly on universities because of their unique resources, capacity and qualifications in the area of knowledge-building, education and technology transfer, and their ability to bridge all sectors of the transportation enterprise.

The vast majority of scientists and researchers are located in institutions of higher learning. The largest proportion of government, corporate, and other institutional investment in research, development, and education is in universities. Compared to other cabinet departments DOT invests far less in university-based research. However, DOT's policy is to leverage its comparatively small investment by strategically co-investing with others, enabling it to take full advantage of all the talent, resources, and knowledge being developed in universities. The benefits to the transportation enterprise from this leveraged co-investment strategy far exceed the likely gains of investing in any one corporation or specialized laboratory.

Transportation is increasingly a multi-disciplinary field. Advances, such as ITS, and institutional changes resulting from ISTEA and the CAAA necessitate research and education efforts in engineering, planning, and the social and behavioral sciences. The university community offers a unique environment where each of these specialties may be brought to bear on specific transportation issues and research problems. Moreover, the "business" of universities is the creation of new knowledge and education. DOT views the capacity of universities to assist the Department in education as integral to its mission of promoting transportation and ensuring that there is a well trained work force available to the transportation enterprise.

In addition to providing a mechanism for co-investment and education, universities are able to provide a vital bridge to all transportation stakeholders. For example, universities conduct considerable research on projects funded by the freight community and local governments. The Department's work with universities thereby provides another means by which DOT learns of specific issues that may impact transportation, but that are not yet a major focus of the Federal Government.

Near Term Efforts

The near-term efforts in this area include the continued support and management of the University Transportation Centers Program, University Research Institutes; National Highway and Transit Institutes; Dwight David Eisenhower Transportation Fellowship Program; State Planning and Research Program; and the Small Business Innovation Research Program.

University Transportation Centers Program²⁰

FY	1997	1998	1999
Funding	12,000 ²¹	12,000 ²²	NA
FTE	NA	NA	NA

DOT's University Transportation Centers Program (UTCP) represents a major investment in fostering transportation innovation and in developing human capital on a variety of transportation issues in its nationwide network of universities. The UTCP was established in 1987 and is managed centrally, with funding provided by both highway and transit titles of ISTEA. The Federal funds are matched by sources such as industry, the universities, and State and local governments. Funded by FTA and FHWA and managed by RSPA, the program's

²⁰The UTC Program funded through FHWA and FTA, and is classified as a System Assessment activity (see discussion in Section III, Chapter 1).

²¹\$6,000k under FHWA budget, \$6,000k under FTA budget.

²²\$6,000k under FHWA budget, \$6,000k under FTA budget.

missions are to strengthen education, research, and technology transfer of transportation knowledge and skills by addressing regional and National transportation needs. A minimum of 5 percent of each UTC's total funding is dedicated to technology transfer.

Ten university consortia were competitively selected in 1988, 1 in each of the 10 standard Federal regions. In the current program, each center has a lead university and additional participating universities. By the end of its fifth year, the program encompassed a total of 63 universities (including 7 minority institutions) and involved more than 1,400 students and faculty. The ten regional centers were recompeted for the last three years of the authorization (FY 95-97). Three additional National centers were established by DOT in 1992 as a result of ISTEA. The new UTC's are: 1) the National Center for Transportation Management, Research, and Development at Morgan State University in Baltimore, 2) the National Rural Transportation Study Center at the University of Arkansas in Fayetteville, and 3) the Center for Transportation and Industrial Productivity at New Jersey Institute of Technology in Newark.

Education, research, and technology goals received strong affirmation as Congress extended the program for six additional years. Evaluation of proposals and selection of programs for future years are currently in progress.

University Research Institutes^{23, 24}

FY	1997	1998	1999
Funding	6,250	6,000	NA
FTE	NA	NA	NA

ISTEA also established the *University Research Institutes (URI)* program, which is also managed centrally for the Department by RSPA but funded by FHWA. The intent of the program is to provide centers of excellence in transportation research. The Institutes include the following: 1) a National Surface Transportation Policy Studies Institute based at San Jose State University; 2) an Infrastructure Technology Institute, based at Northwestern University; 3) an Urban Transit Institute, based at both North Carolina A&T University and the University of South Florida as lead of a consortium of Florida universities; 4) an Institute for IVHS Concepts, based at the University of Minnesota's Center for Transportation Studies, which is

²³The URI program is classified as a System Assessment activity.

²⁴ President Clinton's proposed *National Economic Crossroads Transportation Efficiency Act (NEXTEA)* would consolidate and modify the University Research Institutes and the University Transportation Centers programs. It would continue the ten regional university transportation centers. The current array of national centers and institutes, each of which concentrates on a particular transportation issue specified in statute, would be consolidated into a single system.

managed by FHWA in conjunction with other ITS Regional Centers of Excellence; and 5) an Institute for Transportation Research and Education based at the University of North Carolina.

Together the UTC's and URI's will help attract quality students toward careers in transportation, and will facilitate communication between state DOT's and other transportation organizations. In addition, they will provide effective technology transfer of research resulting from efforts at the Centers and Institutes.

The major fiscal year 1998 objectives are to continue to fund promising research efforts that represent advances in surface transportation. Research projects are chosen after funds are granted to the member institutions.

ITS Research Centers of Excellence

FHWA R&D has three competitively selected and one Congressionally mandated Research Centers for Excellence (RCEs) established to provide ITS research solutions, promote ITS technologies, and provide professional development to prepare ITS professionals to design, build, and operate intelligent transportation systems. These are located at the University of Michigan, Texas A&M, Virginia Polytechnic Institute and State University, and the University of Minnesota. Recent major accomplishments of these institutions are wide-ranging, and include:

- Research in Commercial Vehicle Operations involved the application of Automated Vehicle Location (AVL) systems to snow and ice removal and the extension of AVL systems to include dynamic route guidance for vehicles in a time-sensitive (e.g., Just-In-Time) delivery environment.
- One center developed and implemented in the field a first-generation real-time multimodal traffic adaptive control system.
- One center has developed and demonstrated a Wide-Area Incident Management Software System (WAIMSS) as well as point diversion modules, which is scheduled for use in the new Suffolk, Virginia Traffic Management System (TMS) in 1997.
- Center researchers have developed and fabricated optical fiber-based sensors for vehicle (i.e., cars and truck) classification, weigh-in-motion, and visibility condition classification.
- RCE researchers have developed and tested sensor and communication technology, including a wireless digital communication receiver, ultra-wide band communications,

and a passive acoustic sensor for vehicle detection, position location, and automated control.

National Maritime Enhancement Institutes

In 1990, the Maritime Administration designated four universities as National Maritime Enhancement Institutes in recognition of their ability to provide leadership in solving problems confronting the maritime industry. The designation of Institutes was authorized under Public Law 101-115 (authorizing appropriation for fiscal year 1990 for the Maritime Administration). The four Institutes are the University of California at Berkeley, the Louisiana State University, the Massachusetts Institute of Technology, and Memphis State University.

The University of California was designated for technology research relating to the maintenance and operation of shipping fleets including human factors issues. The Louisiana State University chooses to be known as the Institute for Maritime Transportation Systems Research. The Massachusetts Institute of Technology designation was made to the DOT Region I University Transportation Center at MIT for the full range of activities authorized by the legislation. The Memphis State University together with the University of Tennessee and the University of Kentucky are known as the Inland Waterways Studies Institute. Each of the Institutes is either part of a regional DOT University Transportation Center or is part of a university consortium with multimodal, multidisciplinary research capabilities.

No funding is available for the administration of the National Maritime Enhancement Institutes. The fiscal year 1998 objective for the Institutes is to provide a resource for the implementation of the funded Maritime Administration research program.

National Cooperative Highway Research Program

The NCHRP is a unique applied research program designed to respond to the needs of the state highway and transportation departments by solving important operation problems in highway transportation. NCHRP resources are a combination of state voluntary contributions of 5.5 percent of their Federal apportionment of planning and research funds. The NCHRP is administered by TRB under a three-party agreement between FHWA, National Academy of Sciences (NAS) and AASHTO. Since its inception in 1962, the NCHRP has administered 789 research projects with total funding of more than \$149 million. The NCHRP's close association with AASHTO and its position within the National Research Council have enabled the program to carry out many important research tasks resulting in practical products used by state highway agencies and others.

Major activities planned for fiscal year 1998 include:

- Through AASHTO, solicit and administer research on behalf of the various State departments of transportation to address commonly shared problems.

- Support ongoing projects for state-of-the-practice reports, legal histories on topical issues, IDEA topics, international information sharing, and concerns affecting the administration of State departments of transportation.
- Prepare various guidance documents on multimodal transportation planning, geographic information systems, traffic control devices for the aging driver, impacts of economic trends on transportation, implementation of transportation control measures, and HOV (high occupancy vehicle) systems.
- Develop models for determining carbon monoxide concentrations at intersections and vehicle emissions.
- Make significant research contributions to the Highway Capacity Manual for the year 2000.
- Support the implementation of SHRP products, primarily SUPERPAVE, through additional research.
- Develop a strategic plan for roadside safety research.
- Produce several training programs on construction activities.
- Support activities for implementing a new philosophy in bridge design.
- Produce a design catalog for pavement types.

Transit Cooperative Research Program (FTA)²⁵

FY	1997	1998	1999
Funding	8,250	8,250	NA
FTE	NA	NA	NA

The TCRP is an important component of the Federal Government's support of transit innovation. Since it was authorized in 1961 by ISTEA, the TCRP has been producing a continuing flow of research results of significant importance to the transit industry, which is directly involved in identifying and prioritizing TCRP research projects. The TCRP emphasizes developing near-term research solutions that address immediate, practical needs, providing funds to solve contemporary problems and develop needed improvements in the efficiency and safety of transit operations, customer service, assessment of transit's benefits

²⁵The TCRP is classified as a System Assessment activity.

and economic impacts, marketing, maintenance, management practices, human resources development, and planning techniques.

The TCRP fosters increased cooperation among Federal, state, local and private sector research organizations in the transportation field, improving communications and facilitating technical information transfer. Participants include members of the transit community and researchers throughout the Nation. The TCRP Oversight and Project Selection Committee (TOPS), an independent governing board, develops a research and demonstration agenda for TCRP that is responsive to the needs of the transit industry. The Transportation Research Board administers the program, convening expert technical panels to define the scope of projects, evaluate proposals and guide projects through completion. The American Public Transit Association ensures that research results are widely disseminated to the transit industry.

The TCRP serves as an important, broad-based complement to FTA national R&D programs, which must be more narrowly focused on a limited number of nationally significant innovations. The TCRP fosters greater cooperation among transportation providers and suppliers, State and local agencies and other key segments of the industry in conducting problem-oriented research relevant and useful to the industry. TCRP meets the near-term research needs of the transit industry by consolidating, focusing and strengthening research directly responsive to the day-to-day operational problems of transit.

Dwight David Eisenhower Transportation Fellowship Program (FHWA)²⁶

FY	1997	1998	1999
Funding	2,000	2,000	NA
FTE	1.0	1.0	NA

The Dwight David Eisenhower Transportation Fellowship Program was authorized by ISTEA in 1991. Its purposes are to attract the Nation's brightest minds to the field of transportation, to enhance the careers of transportation professionals by encouraging them to seek advanced degrees, and to retain top talent in the transportation community of the United States. The program encompasses all areas of transportation and awards fellowships to students and faculty members from colleges and universities across the United States.

The Eisenhower Transportation Fellowship Program awards five fellowships: Graduate Fellowships, Grants for Research Fellowships, Historically Black College and Universities (HBCU) Fellowships, Hispanic Serving Institutions (HSI) Fellowships, and Faculty Fellowships. The Program has a Tribal Colleges Initiative whose purpose is to identify transportation activities at tribal colleges in order to provide fellowships for Native American students and faculty. The Program is administered by the National Highway Institute in the

²⁶The Eisenhower Transportation Fellowship Fund is classified as a Physical Infrastructure activity.

Federal Highway Administration and provides a critical investment in advancing, improving, and maintaining technical expertise in the transportation community.

In fiscal year 1998, the Program expects to award fellowships to over 120 students and faculty members, including at least four fellowships to Native American students and faculty members.

State Planning and Research (FHWA)²⁷

FY	1997	1998	1999
Funding	80,367 ²⁸	80,367	NA
FTE	NA	NA	NA

Individual states and FHWA cooperate in the support of highway R&D through the State Planning and Research (SP&R) Program. States receive 2.0 percent of their total Federal-aid highway apportionment as SP&R funding to be used for conducting highway planning and research activities. State highway agencies allocate the SP&R funds between planning and research. In FY 1997, states will spend about \$80 million of SP&R funds for research, development, and technology transfer activities. States also have an option to pool their SP&R and other available funds in nominal amounts to sponsor National and regional cooperative studies of common interest and concern.

Major activities for fiscal year 1998 include the completion of state research on quality assurance in highway design, construction and maintenance, improving traffic control devices, countermeasures to address bridge pier scour, and improving pavement drainage.

Small Business Innovation Research Program

The Small Business Innovation Development Act of 1982 (P.L. 97-219), reauthorizing legislation (P.L. 99-443), and Small Business Research and Development Act (P.L. 102-564) seek to encourage the initiative of the private sector and to use small and minority-owned businesses as effectively as possible in meeting Federal R&D objectives. To comply with the statutory obligations of the Act, DOT has established a SBIR Program which conforms to guidelines and regulations provided by the Small Business Administration (SBA). Annually, small businesses are solicited to submit proposals for innovative research that address high-priority requirements of the Department and have the potential for commercialization. The

²⁷The State Planning and Research Program is classified as a Physical Infrastructure activity.

²⁸As discussed in the text, this funding (and that for FY 1998) represents a 2.0% set-aside of State Federal-aid highway apportionments.

activity is funded by the DOT operating administrations, and by statute has to be a given a percentage of the Department's extramural research budget.

The DOT SBIR Program is managed by the John A. Volpe National Transportation Systems Center in Cambridge, Massachusetts. The Volpe Center develops integrated systems approaches to critical transportation issues, particularly those that cut across multiple modes of transportation. Its unique role as a multimodal center assures that it will direct the DOT SBIR Program to stimulate technological innovation by inviting small businesses to submit research proposals that address high priority research issues confronting transportation. In FY 1996, SBIR awards were made in a number of surface transportation research areas, including:

Phase I Awards (6 Months)

Energy Absorbing Utility Poles
Material for Composite Bridges
Basalt Fiber Reinforced Concrete
High-Speed Composite Flywheels
Internet-Based Highway Capacity Software
Intermodal Operations Planning System

Phase II Awards (24 Months)

Transportation GIS Model
Vehicle Axle Detectors
Fatigue Crack Detection
Transit Decision Support System
Advanced Traffic Enforcement Technology
Dynamic Intrusion Sensing System

The Department's SBIR Solicitation for FY 1997, available in hard copy or through the internet, closed for receipt of proposals on May 1, 1997, but was available for access electronically through the World Wide Web (WWW) site maintained by the Volpe Center (<http://www.volpe.dot.gov>). Priority research topics for surface transportation include, but are not limited to the following:

- Portable Microwave System for Measurement of Fatigue Cracks
- Incorporating Remotely Sensed Data in the Transportation Planning Process
- Portable Sensor for Accurate Speed Measurements
- Development of Breakaway Guy Wires for Utility Poles
- Vehicle-Based Animal Deterrent
- Pavement Ice Sensors
- Feasibility of Vehicle Borne Detection of Broken Rail
- Turnout Improvements for Enhanced Safety
- Inspection/Test Method for Finding/Sizing Crack Type Defects in Railroad Tank Cars Covered with Insulation or Thermal Jackets
- Improved Knuckle Coupler with Air and Electric Connections
- Safety Intrusion Detection Devices - Transit Applications
- Improved Maintenance Techniques Linked to Capital Development
- Transit Fare Collection Decision Models for Fare Policy and Cost Analysis
- Unobtrusive Eyelid Closure and Visual Point of Regard Measurement Device
- School Bus Interior Flame Retardant Materials
- Application of Advanced Technology to Reduce Driving While Suspended
- Automated Crash Scene Documentation

Consistent with NSTC recommendations for transportation-related strategic focus areas for the SBIR, the Department is considering the following topics, among others, for its FY 1998 SBIR Solicitation: composite-bonded aircraft structures inspection; systems assessment and modeling of interface environments; crack detection in bridges using remote sensing; and concrete-composite material manufactured from recycled plastics. The final solicitation will be built upon both these recommended research areas and the emergence of priorities in other areas.

CHAPTER 8

DOT R&D FACILITIES AND ADMINISTRATIVE SUPPORT FOR R&D

In order to carry out its responsibilities for the management of DOT-funded R&D, and the actual implementation of a number of key activities, the Department devotes a portion of its funding and personnel to administration of these resources. Near-term funding and FTE levels devoted to R&D administration are as follows:

Operating Administration	Funding			FTE		
	1997	1998	1999	1997	1998	1999
FHWA ²⁹	10,026	10,327	NA	NA	NA	NA
NHTSA ³⁰	12,600	13,082	NA	NA	NA	NA
FRA ³¹	2,181	2,283	NA	2	2	NA
MARAD	0	0	NA	NA	NA	NA
FTA ³²	2,223	2,270	NA	NA	NA	NA

In addition, DOT maintains several actual facilities in which it conducts research supporting Departmental missions. Near-term funding requirements associated with maintaining and refurbishing these facilities are as follows:

²⁹Considered a Physical Infrastructure activity (see discussion in Section III, Chapter 1).

³⁰Considered a System Assessment activity.

³¹Considered both a Vehicle- and Physical Infrastructure-related activity.

³²Considered a Human Behavior-related activity.

Fairbank Building Renovation (FHWA)³³

FY	1997	1998	1999
Funding	500	2,000	NA
FTE	0.20	0.25	NA

The objective of this activity is to complete the renovation of the Fairbank Building, which houses a number of laboratories, and office space for FHWA researchers. The first two stages of renovation are now complete, including new rest rooms; elevator; heating; ventilation and air conditioning equipment; as well as renovation of five laboratories (the bituminous mixtures, concrete, corrosion, pavement binders, and photographic labs). The Stage 3 contract is underway. This stage will complete the renovations of all laboratories except for the aerodynamics laboratory.

Work to be performed in FY 1998 includes completion of office space and corridor renovations (including installation of a sprinkler system), renovation of the aerodynamics laboratory, removal of asbestos, provision of handicap access at main entrance, and insulation of exterior walls and attic.

Vehicle Research and Test Center (NHTSA)³⁴

FY	1997	1998	1999
Funding	799	799	NA
FTE	0.2	0.5	NA

The Vehicle Research and Test Center (VRTC) is the in-house research, development, test and evaluation laboratory for the National Highway Traffic Safety Administration (NHTSA). VRTC provides engineering analysis in support of NHTSA defect investigations and rulemaking initiatives. Long term research programs in the areas of biomechanics, crash avoidance and crash worthiness are also performed at VRTC.

VRTC is located on contractor owned property. The agency leases the building and work areas. All expenses associated with maintenance of the facility are covered by the government via VRTC administrative funds. These include: utilities (heat, sewage disposal, electricity, phone equipment), lease of GSA vehicles, janitorial services, supplies, copier expenses, etc.

VRTC houses over \$2 million worth of specialized test fixtures and equipment. A significant amount of this equipment is ADP and electronics equipment. Calibration, maintenance, replacement and upgrade of this equipment is required on a yearly basis.

³³Considered a Physical Infrastructure activity (see discussion in Section III, Chapter 1).

³⁴Considered a vehicle-related activity.

Department approval has been granted for a space expansion at VRTC. In response to a request for more space, the contractor has proposed relocating VRTC to a new building at the same location. When this occurs, increased lease and maintenance costs would be expected, as well as relocation costs. Negotiations regarding the design, cost and timing of the relocation are ongoing and nearing completion. A move in FY98 is anticipated.

R&D Facilities (FRA)³⁵

FY	1997	1998	1999
Funding	420	850	NA
FTE	1	1	NA

This program area is intended to protect the Government's capital investment in facilities and equipment at the Transportation Technology Center (TTC) in Pueblo, Colorado. A world-class proving ground for railroad equipment, the government-owned TTC represents a facility capital investment of over \$200 million. While the facility is operated for FRA under a no-cost contract with the Association of American Railroads (AAR), the AAR is only required to provide routine maintenance for buildings and equipment. The R&D Facilities Program is therefore essential for sustaining the viability of TTC's research capabilities by continuing to replace or refurbish facilities or equipment that can no longer be economically maintained by AAR. Current activities include environmental law compliance and R&D facilities restoration. Environmental Law Compliance includes completing construction of new wastewater treatment facility. R&D Facilities Restoration includes:

- Completion of upgrade of Railroad Test Track to permit 150 mph testing of Amtrak's Northeast Corridor trainsets.
- Completing post-closure groundwater monitoring in wells at solid waste management units.
- Upgrading electrical equipment in DC substations.
- Replacing servo-controllers on the Simuloader in the Rail Dynamics Laboratory.
- Installing heavier running rail on approximately two miles of 3rd-rail DC-powered test track to allow testing of dual-mode locomotives.

³⁵Considered both a Vehicle- and Physical Infrastructure-related activity.

New initiatives scheduled for FY 97 include:

- Rebuilding a trueing machine that enables railroad car steel wheels to be reprofiled without dismounting from truck assembly;
- Installing heavier running rail on approximately 2 miles of 3rd-rail test track to enable testing of dual-mode locomotives;
- Upgrading on-site ambulance support; and
- Re-roofing rectifier substation #2.

Ongoing projects include the complete restoration of all solid-waste management units.

Key FY 1998 milestones will include:

- Initiation of testing of Amtrak's Northeast Corridor trainsets.
- Upgrading emergency vehicles used for ambulance and firefighting support services.
- Re-roofing three buildings used for secondary support facilities.

SECTION IV. CONTRACTING PROCEDURES

Section 6009(b)(3)(C) of ISTEA calls for:

Recommendations on changes needed to assure that Federal, State, and local contracting procedures encourage the adoption of advanced technologies developed as a consequence of the research programs in this Act.

Experience has shown that Government contracting procedures significantly impact the adoption of advanced technologies. While it is understood that many traditional procedures (e.g., low-bid contracting with performance specifications) are in place to reduce risk, protect investments, and ensure accountability, at times such traditional procedures have the dual effect of discouraging innovation and failing to support the overall purpose of reducing life cycle costs through improved performance and durability.

As an example, current highway regulations facilitate separation of design from construction, primarily to obtain as much competition as possible during the highest cost phase of construction programs. This process also opens more opportunities to small and mid-sized construction firms which may not have architectural and engineering capabilities. By adding another party and step to the acquisition process, however, the procedures raise questions of contract performance and product liability responsibilities whenever new or unusual designs or construction technologies are attempted. Local government buyers tend to avoid "unnecessary" risks until innovations are thoroughly tested and available on the open market.

In responding to ISTEA's call for contracting procedures that promote advanced technologies, the Department is committed to determining which practices impede innovation and the alternatives or incentives that are available to encourage the use of innovations. The October, 1994 Acquisitions, Reengineering, and Realignment Task Force (ARRTF) studied DOT's contracting and acquisitions procedures, and recommended ways to streamline the present system.

A number of innovative recommendations have resulted from this process, many of which have been implemented in recent months. The Department's new Re-invention Laboratory is one example of the outgrowth of these efforts. Modeled after other recently established re-invention laboratories within the Federal government, including NASA's, the Lab was created to increase flexibility and innovation in DOT's acquisition processes by allowing freedom, i.e., a waiver, from compliance with various administratively-imposed requirements. This is done primarily through the Agency's implementation and interpretation of the statutes and regulations. As an example, the regulations do not require proposals to be in written form, so oral proposals are now often used. With the Re-invention Lab, DOT now also has a means for experimenting with pilot programs for re-engineered processes. Among the issues the Re-invention Lab addresses include: establishing performance measurements and standards to

assess the success of pilot programs; assessing and managing the risks associated with implementing changes such as greater delegation of authority and reduced file documentation; re-engineering other processes and conducting pilot programs to determine potential benefits; influencing the development of Federal regulation and new procurement legislation; and addressing the multitude of cultural issues in the DOT procurement community.

In addition to these efforts, DOT has increasingly been making use of the flexibility offered by the provisions of ISTEA. This has enabled the use of a number of innovative financing tools including leveraging tools (e.g., flexible match; bonds and debt; ISTEA Section 1021 Loans; ISTEA Section 1044 Toll Investment Credit) and cash flow tools (advance construction; partial conversion of advance construction; phased funding; and tapering) and has promoted the increasingly necessary trend of public/private partnerships.

This chapter discusses a number of these innovative new financing tools, programs, and task force efforts along with an overview of current contracting practices and recent Federal actions on procurement laws and regulations.

Overview of Current Contracting Practices

Since DOT does not own nor operate surface transportation systems, contracts for all but about 3 percent of federally assisted surface transportation programs will be placed and managed by DOT grantees or subgrantees, such as State, county, and city governments, regional and municipal authorities, special districts, and Amtrak. Of the contracts placed by DOT, the largest dollar amount is for building and rehabilitating roads in National Parks and Forests. The remainder (only about 1 percent) of the Department's annual surface transportation funds is used for DOT sponsorship of research, development, training, technical assistance, and technology transfer.

In the future, the number of grantees and subgrantees can be expected to increase. More decision making responsibilities have been vested in State and local governments by flexible funding provisions of ISTEA. Nationally, funding emphasis has shifted from completing the Interstate System to maintaining and improving the National Highway System, including local highways and access to intermodal facilities. Congestion mitigation, air quality, and regional traffic management systems can be expected to lead to increased involvement of city and county governments and regional agencies.

Through the Intelligent Transportation Systems (ITS) program authorized by ISTEA, the Department has increased its emphasis on using advanced sensing, computing, and communications technologies to improve the productivity of existing infrastructure. ITS developments will undoubtedly lead to increases in the variety and quantity of local procurements of hardware and software. This growing diversity of agencies and products

underscores the need for a continuing effort by DOT to understand the effects of Government contracting practices at all levels.

General Requirements for DOT Grantees

Procurement procedures for State and local governments under grants and cooperative agreements that use Federal funds are set forth in title 49, Code of Federal Regulations (49 CFR, Part 18), "Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments" (the common grant management rule). The rule applies to all grants and subgrants awarded by DOT. Issued in 1988, the rule called for a less intrusive Federal role in grantee procurement activities. It responded to an Executive Order directing Federal agencies not to substitute their judgment for that of the recipient unless the matter is primarily a Federal concern, and that agencies, to the maximum extent feasible, defer to the States to establish standards, rather than setting National standards.

The common grant management rule prohibits Federal agencies from imposing additional administrative requirements, unless required by statute, and encourages grantees to avoid detailed or burdensome application requirements for subgrants. A key provision is that States are to follow the same policies and procedures they use for procurements using non-Federal funds. However, the procurements must conform to applicable Federal law. Grantees and subgrantees are to follow the provisions of Part 18 and use their own procedures reflecting applicable State, local, and Federal laws. Procurement transactions are to be conducted in a manner providing full and open competition. While this rule covers the majority of grantees, the States are authorized to follow their own procedures used for procurements from non-Federal funds. Noncompetitive procurements are permitted only under exceptional circumstances.

49 CFR Part 18 invokes Federal laws that apply to contracts awarded under any federally financed program. Examples are: Equal Opportunity Employment, Anti-kickback, Clean Air, Clean Water, and Davis-Bacon. For the convenience of State and local government grantees, and to assure universal application, FHWA requirements specify use of a uniform contract attachment. FTA lists laws and regulations which apply specifically to transit programs in its master agreement.

The grant management rule for universities and other not-for-profit institutions is 49 CFR Part 19.

Federal Aid Highway Programs

The objectives of highway design and construction contracting procedures are to minimize costs and risks, obtain essential uniformity in nationwide highway systems, and accelerate the rate of new construction nationally. In addition to the common grant rule, 23 CFR Parts 172, 633, and 635 provide detailed contracting procedures and forms for engineering and design

contracts and for construction contracts. For engineering and design contracts, the regulations permit any form of competitive negotiation that uses qualification-based procedures. For highway construction, the regulations require low-bid procedures.

The regulations have been undergoing evaluation and refinement since the Federal-aid Highway Program began in the 1950s. They have been modified to respond to changes in National policies and laws and have been continuously tested by litigation. As was mentioned earlier, highway regulations facilitate separation of design from construction, primarily to obtain as much competition as possible during the highest cost phase of construction programs; a process that also opens more opportunities to small and mid-sized construction firms which may not have architectural and engineering capabilities. This additional step to the acquisition process, however, raises questions of contract performance and product liability responsibilities whenever new or unusual designs or construction technologies are attempted. In turn, risk-averse local government buyers tend to avoid "unnecessary" risks until innovations are thoroughly tested and available on the open market, and at competitive cost.

FHWA is able to use the greater flexibility of its R&D and demonstration programs to develop and test new construction technologies, materials, and processes. FHWA grantees are encouraged to participate in advanced technology programs through the NCHRP and the agency's R&D and special experimental projects. The special experimental projects include evaluating innovative contracting practices such as cost-plus-time bidding, lane rental, design-build contracting, and warranty clauses.

Building Partnerships with Innovative Financing

With current constraints at the Federal level, Federal funding in many programs will undeniably be limited in the future. Coupled with this, State and local governments are under similar constraints and face competing demands for various vital needs. The best response to this may likely be the new trend toward partnerships with the private sector. Many of the United States' international competitors already employ this tactic.

In January of 1995, President Clinton announced the "Partnership for Transportation Investment." Also known as "Innovative Financing," the term covers a broad range of strategies including the use of leveraging and cash flow tools. DOT's involvement with Innovative Financing began with provisions in ISTEA that allowed experimentation with varied ways of financing advanced technology projects. Over the last three years, DOT has aggressively pursued such experiments.

Many such projects employ single financing techniques, while others combine techniques to obtain the greatest benefits from the flexibility allowed under such programs as the FHWA's Test and Evaluation 045 (TE-045) program (a program which allows for the testing of many of the Innovative Financing ideas generated). Incentives for using Innovative Financing, and ones which have been realized, include the ability to complete projects more quickly as well as

the opportunity to begin more projects. Moreover, Federal dollars have leveraged additional dollars and private investment in infrastructure has grown.

The primary goals of Innovative Financing are to: create incentives for the States to take full advantage of ISTEA's financing opportunities; to learn what new financing strategies and policies work best and make necessary changes; to assist the States in their efforts to leverage their current funding and produce additional funds - both public and private; and to move projects into construction more quickly than under traditional financing procedures.

Innovative Financing, working within the existing statutory framework, allows many of the existing restrictions and requirements to be waived and gives local decision makers greater flexibility and authority. Such experimentation is critical in that the current system of paying for projects only through grant reimbursement is increasingly being considered outdated; the "red tape" required slows projects and increases costs, making it difficult for States and localities to involve private investors.

These innovative financing tools, designed to make more funds available to transportation providers, include leveraging tools such as: Flexible Match; Bonds and Debt; ISTEA Section 1012 Loans; and ISTEA Section 1044 Toll Investment Credits. Other innovative tools used, referred to as cash flow tools, include: advance construction; partial conversion of advance construction; phased funding and tapering.

As an example of *Flexible Match*, the Maine Department of Transportation is constructing an intermodal truck-to-rail transfer facility near the Town of Fairfield. Located about one mile from the Interstate, the facility will provide for the transfer of truck freight from major U.S. highways to key rail lines, both in Maine and throughout New England. Under the Innovative Financing effort, a private rail company is contributing material, equipment, and services for use in the project. The State is crediting the value of the rail contributions toward the State's share of project costs. The rail contribution saves the State \$1.57 million, which can be used elsewhere for transportation.

Bond and Debt Financing is demonstrated by the Conway Bypass project in South Carolina. The South Carolina DOT plans to build a link between U.S. 17 and other major roads that lead to the Grand Strand/Myrtle Beach area, increasing access to the State's largest tourist area. FHWA is applying the TE-045 ISTEA Section 1012 loan approach to a non-toll facility with a dedicated revenue repayment source. This loan for the estimated construction cost of the project provides cash to service the bonds supporting the project. Bond principal and interest on the project will be repaid using TE-045 flexibility. By combining Innovative Financing and innovative contracting, this project is expected to save over \$100 million, with construction accelerated by 20 years. Local sales tax revenues will also fund a portion of the project.

As an example of the *ISTEA Section 1012 Loan*, the Texas Department of Transportation has constructed an 8-lane bridge and supporting facility between Laredo, Texas and Nuevo

Laredo, Mexico. The project includes a loan of \$11 million from the State to the City of Laredo. The loan financing the bridge, which is expected to cut congestion brought about by the increased traffic expected from NAFTA, will be paid for by toll revenues and rental income from other users of the facility.

The Maryland Department of Transportation used *Section 1044 Credits* earned from toll revenue expenditures to make needed highway capital improvements. Under an innovative approach to the Section 1044 Maintenance of Effort requirement, the State has used about \$18.9 million in toll credits in FY 1995 based on a prospective Maintenance of Effort test. State credits will be used as the State share for funds on the I-70 project near Frederick, Maryland among others. This frees up State funds (which may otherwise have been required to meet matching requirements) for use on other projects.

The Butler County Highway in Ohio is an example of using *Advance Construction*. The Ohio DOT will construct a four-lane, 10.3-mile road and extra lanes on the Interstate to accommodate a proposed interchange. The project, which costs \$95 million, is based on State legislation that established a transportation improvement district in the area. Because of the good prospect of future Federal funds, the State can borrow more easily to finance the project and, as a result of Advance Construction eligibility and flexibility, the State can obtain better financing for an intergovernmental loan and/or private bonds for the project.

Interstate route improvements in Pennsylvania, including three major reconstruction projects along high-volume interstates and expressway routes, are currently being financed through *Partial Conversion of Advance Construction* funds. The Federal share of all three projects is approximately \$45 million. The State will partially convert Advance Construction projects, saving as much as 5 percent of the State's FY 1995 obligational authority and making it possible to advance other "ready-to-go" projects earlier in the authorization period.

In New Jersey, a new viaduct will be constructed and three bridge decks replaced using *Phased Funding*. In this way, the State can spread costs over two years and make more efficient use of Federal funds, enabling the project to begin a year early. Phased Funding will enable several other bridge replacement-eligible projects which might otherwise have been delayed six to eight months to be obligated at a significantly faster pace.

The Michigan DOT has utilized *Tapering Non-Federal Matching Shares* in their recent widening of a State truck line aimed at increasing capacity to alleviate congestion problems. The project costs for Phase II are approximately \$70 million with authorized Federal participation of \$57.3 million. Tapering will enable Michigan to achieve better cash flow management during the riskier early project stages.

On November 28, 1995 Congress enacted P.L. 104-59, the National Highway System Designation Act of 1995. Sections 311, 313, and 322 of this Act take innovative financing one step further by making permanent the financing technology demonstrated under TE-045.

In addition, Section 350 established a 2-year State Infrastructure Bank (SIB) Pilot Program that will allow States to recycle transportation funding and leverage additional investment in transportation infrastructure over a long-term period. The Department views the SIB Pilot as a means of advancing a multiple financing strategy.

While many of the early projects utilizing Innovative Financing have been ones to build new roadways, other modes, including transit, rail, and aviation, have high potential. For example, airport construction, which relies on the capital markets for as much as three-quarters of its funding, has long been a model for involving the private sector in public projects.

As an example, Northern Southern Railroad recently paid to add a third track on a rail right-of-way in Cincinnati, greatly reducing rail congestion. The Railroad will be reimbursed for this over time through the State's ISTEA allocation using Advance Construction Funding.

Three FTA grantees, the Chicago Transit Authority (CTA), the Bi-State Development Agency (Illinois and Missouri) and New Jersey Transit (NJT), recently concluded innovative financing transactions that together generated nearly \$57 million dollars in additional transit revenues. All three are U.S. tax-based transactions involving U.S. taxpayers. While the transactions confer certain tax deferment and depreciation benefits, they will nonetheless be "tax-positive" to the Treasury, and earn approximately \$65 million as a result. The CTA entered into a U.S. leveraged sale/leaseback ("Pickle" lease) of approximately \$831 million in rail cars. CTA transferred title to the vehicles to a private investor, and will lease them back over a 20-year period. The CTA has received approximately \$47 million in profits. Bi-State concluded a similar Pickle lease of \$59 million in rail cars, and received \$3.8 million in profit. NJT closed a Pickle lease of some \$125 million in locomotives and rail cars, and received \$6 million in profit. The lease terms allow the grantees to maintain control and use of the equipment in mass transit service, as required by Federal law. They regain title to the equipment at the end of the lease period.

Transit Equipment and Construction Contracts

Although DOT-assisted transit programs follow the common grant management rule, FTA maintains a circular, (C 4220.1D, "Third Party Contracting Requirements") to assist grantees and regional offices in interpreting the procedures that are specifically applicable to transit agency procurements. The circular and its referenced laws and regulations emphasize that all procurement transactions are to be conducted in a manner providing full and open competition. In addition, 49 USC 5323(h) and 49 USC 5307(d)(1)(E), formerly sections 3(a)(2)(C) and 9(e)(3)(E) of the Federal Transit Act of 1964, as amended, forbid the use of Federal grant or loan funds to support procurements utilizing exclusionary or discriminatory specifications.

However, grantees are encouraged to use "value engineering" clauses and may use procurement by competitive proposals in lieu of sealed bids. (Value engineering clauses cover situations where a contractor comes up with an idea, after the work has begun, that saves

money. The clause, most often utilized in construction projects, allows for the contractor and government to share the savings.) The competitive proposal method allows consideration of such factors as technical risks, life cycle costs, technical performance, and management approach, as well as initial costs. However, because of State and local regulations most authorities continue to rely on definitive specifications and low-bid contracting, or on low-bids for life cycle costs. Life cycle costs refer to initial and future costs such as maintenance, reconstruction, rehabilitation, restoring, and resurfacing costs over the life of the project.

Unlike the high-volume construction programs of FHWA, most new rail starts, busways, downtown people movers, and urban rail modernization programs have been acquired as systems with contracts tailored individually for the unique circumstances of each project. For purposes of programmatic or technical approvals, major transit programs are often divided into phases; however, separate contracts for design and construction contracts are not required. A variety of design-build methods have been used by transit authorities, including turnkey projects.

On May 7, 1996, FTA launched the publication of the *Best Practices Procurement Manual*. This Manual provides recipients of FTA funds suggestions on conducting third party procurements to assist them in meeting the standards of FTA Circular 4220.1D. The Manual consists of suggested procedures, methods, and examples which FTA encourages. These are based on the Federal acquisition process, Comptroller General decisions, and "Best Practices" of grantees and others in the industry. The Manual is envisioned as an ongoing and expanding document. It will be updated periodically with both new subjects as well as additions or changes to existing subjects. The additions/changes will be based on: (1) changes in statutes, (2) the result of recent court decisions, (3) the need for further clarification, and (4) new or innovative practices of grantees. The Manual is located on the Internet World Wide Web under the FTA Homepage. The internet location enables FTA to provide its customers with the latest and newest information using the fastest means possible. Additionally, FTA solicits "best practices" of its grantees and others in the industry. After review by FTA, new and or innovative practices will be added to the manual.

Acquisitions by DOT

All DOT organizations that acquire supplies and services are governed by DOT's Transportation Acquisition Regulation (TAR) and Transportation Acquisition Manual (TAM) that implement and supplement the Federal Acquisition Regulation (FAR).³⁶ Together these documents provide a detailed set of rules governing all phases of acquisition, including procedures to contract for all products and services, including R&D.

³⁶Section 348 of the Department of Transportation and Related Agencies Appropriations Act, 1996 (Pub. L. 104-50) exempts the FAA from many governmentwide procurement statutes and regulations.

In addition to contracts, DOT employs more flexible cost-shared vehicles like Broad Agency Announcements (BAAs), grants to research institutions, cooperative agreements, other transactions, and Cooperative Research and Development Agreements (CRADAs) to leverage the limited R&T resources available. While the use of CRADAs had been somewhat limited in the past, the FAA - among other modes - has been quite active in using these agreements as the benefits of using them are increasingly realized. CRADAs are cost-sharing vehicles that, through encouraging early industry buy-in, ultimately promote the development of commercially viable products and services. The public and the Department have benefitted considerably from the results of long-standing cooperative research programs with universities, industry and professional associations (e.g., AASHTO, AAR, APTA), and the Transportation Research Board of the National Research Council.

Contracting in the Electronic Age

DOT has increasingly been using such tools as the Internet to both ease and expedite many of the government's contracting and grant procedures. From posting information ranging from university research grants to contract solicitation and award, the Internet is increasing accessibility and, in many ways, promoting the advanced technologies aspired for with the passage of ISTEA.

Among the vast grant- and contracting-related items that are housed on the Internet are: experimental university R&D programs; university transportation-related R&D grants; grant management requirements; contract solicitations and awards; and information on the uses of DOT contracts, grants and cooperative agreements, among other items. With such information readily accessible, the government has essential access to current university and private sector research, enabling both better and quicker assessment of available research and technologies. At the same time, the Internet provides universities and the private sector access to the latest information and opportunities in DOT's contracting and grant environments.

In a climate where it is increasingly felt that federally-sponsored research and development should be pushed toward cooperative funding, the Internet--by increasing information flow--is enhancing the opportunity for such partnerships. For example, the Department's two most recent SBIR Program Solicitations both were made available on the World Wide Web (WWW) site for the Volpe National Transportation Systems Center.³⁷ Many other DOT RFPs and CBD notices are available through the Department's WWW site,³⁸ and a wealth of procurement information can be accessed via the Small Business Administration (SBA) WWW site.³⁹

³⁷The site address is <http://www.volpe.dot.gov>. The closing date for the FY 1997 solicitation was May 1, 1997.

³⁸<http://www.dot.gov>

³⁹<http://www.sbaonline.sba.gov>

Other items on the Internet that have enabled DOT's contract and grant information to reach a wider audience are the posting of such items as: Executive Orders; various recent rules and regulations changes that affect the grant and contracting environment; and contract reporting requirements, among others. This has been a significant benefit in that all modes now have a common and accessible vehicle to turn to for updated policies and procedures. This has been helpful in setting more uniform standards across the modes.

Recent Federal Actions on Procurement Laws and Regulations

Federal Acquisition Streamlining Act of 1994 (PL 103-355)

On October 13, 1994, President Clinton signed the Federal Acquisition Streamlining Act of 1994 into law. Most of the provisions of the Act are being implemented through changes to the Federal Acquisition Regulation. There are over 90 sections of the law that were addressed through that process. Key provisions affecting R&D procurements that are in effect include:

- Clarification of the agency authority to execute multiple-contractor task- and delivery-order contracts. Within DOT, such model processes were pioneered at RSPA's Volpe Center. The Center's multiple contractor resource base (known as the OMNI program) has been used for over eight years to obtain technical support for projects managed by the Volpe Center. This practice has now been adopted by OST on behalf of all operating administrations.
- On acquisitions of less than \$2,500 or 0.1 % of total project cost, whichever is greater for Buy America provisions, the requirements to reserve procurements for small business and to comply with provisions of the Buy America Acts have been eliminated.
- Establishment of a Congressional policy that Federal agencies should not be required by legislation to award new contracts or R&D grants to specified non-Federal entities, and that any program, project, or technology identified in legislation be procured through merit-based selection procedures.

When fully implemented and translated into rules, other provisions of the Act will undoubtedly assist in accelerating the adoption of advanced technologies developed as a result of programs authorized by ISTEA.

Federal Acquisition Reform Act of 1996

On February 10, 1996, President Clinton signed into law the National Defense Authorization Act for Fiscal Year 1996, which contained, in Division D, the Federal Acquisition Reform Act of 1996 (FARA). In general, FARA amends various provisions of the Armed Services Procurement Act, the Federal Property and Administrative Services Act of 1949, the Office of

Federal Procurement Policy Act, and the Federal Acquisition Streamlining Act of 1994 to further streamline the Federal procurement process. Key provisions include:

- Statutory approval thresholds for justifications for other than full and open competition were increased.
- Offerors excluded from the competitive range, or that are otherwise excluded from the competition prior to selection, may request a debriefing prior to contract award.
- FARA provides for a new "two-phase" selection procedures for the design and construction of a public building, facility or work. Under phase-one, only information pertaining to prospective offerors' technical approach and qualifications are solicited; no cost/price or detailed design information are requested at this phase. Phase-two of the competition solicits technical proposals (design concepts and/or proposed solutions), and cost/price information from those offerors selected following phase-one in accordance with the solicitation.
- FARA provides for special simplified procedures for the procurement of commercial items valued between \$100,000 and \$5 million. This authority is in addition to the authority for simplified acquisition procedures authorized by FASA for acquisitions between \$2,500 and \$100,000.
- FARA exempts contracts and subcontracts for the acquisition of commercial items from Cost Accounting Standards.
- The Procurement Integrity Act was amended in its entirety. In general, the certification requirements have been eliminated, and the intentional disclosure by Government personnel, and the intentional acquisition by any person (other than as is provided by law) of bid/proposal, or source selection information prior to award of a Federal contract is prohibited.

49 CFR Parts 18 and 19, The Grant Management Rules

In April 1995, the Office of the Secretary issued a final rule amending 49 CFR Part 18, raising the dollar threshold for small purchases to \$100,000. The NPRM also proposes to raise the threshold for DOT approval of several grantee agency actions. Although not aimed primarily at stimulating new technologies, the changes are intended to reduce the administrative burden on grantees, and may accelerate the acquisition of studies and expert assistance necessary to introduce technological innovations. With passage of the Federal Acquisition Streamlining Act of 1994, a new simplified acquisition threshold for universities and not-for-profit institutions under CFR Part 19 was set at \$100,000.

23 CFR Parts 420 and 511, State Planning and Research Program Administration

On July 22, 1994, FHWA published a final rule amending these sections to grant States greater responsibility and flexibility for the management and oversight of their research, development, and technology transfer initiatives supported with FHWA planning and research funds. The rule also reflects the requirements in 23 USC 307(c) for research, development and technology transfer activities.

23 CFR Part 637, Quality Assurance Procedures for Construction

On June 29, 1995, FHWA published a final rule that revised its general requirements for quality assurance procedures for construction on Federal-aid highway projects. The revision permits use of contractor testing results in the overall acceptance program and could permit more rapid introduction of advanced construction and testing techniques.

Interim Policy Statement on Life-Cycle Cost Analysis (LCCA)

On July 11, 1994, the Federal Highway Administration (FHWA) published an interim policy statement on life-cycle cost analysis for public comment (59 Federal Register 35404). The interim policy responds to ISTEA requirements to consider life cycle costs in the design and engineering of bridges, tunnels, and pavements. The policy also implements the Presidential Executive Order 12893 of January 26, 1994, "Principles for Federal Infrastructure Investments," that requires benefits and costs to be measured and discounted over the full life cycle of each project. Subparts B and C of the final rule on implementation of ISTEA management systems (23 CFR 500.207 500.307) require use of LCCA for bridge and pavement management systems. LCCA contracting provides an incentive to contractors to adopt new materials and technologies, and monitoring of integrity and prioritization of maintenance, which improve the durability of infrastructure and save costs in the long run.

To support preparation of the policy statement, FHWA and AASHTO held a jointly sponsored symposium in December 1993, to learn more about LCCA practices among States and to identify research, training, technical assistance, and policy-related needs to improve LCCA practices. Issues and research needs identified at the symposium were: how to establish the appropriate analysis period, how to value and properly consider user costs, and how to choose the appropriate discount rate.

Participants in the symposium identified research data needed to predict pavement and bridge performance and forecast future traffic. One significant point brought out was that "...the results of LCCA may favor selection of improvements with higher initial costs in order to achieve significant long-term savings in overall investment requirements. It may indicate, for instance, that more projects warrant reconstruction rather than rehabilitation strategies, that early intervention with preventive maintenance is cost effective, or that somewhat higher designs or levels of service may be appropriate for some facilities." Aside from the important

information gathered at the symposium, offering incentives to encourage use of newest technologies may also promote greater creativity among the States.

Comments on the interim policy statement were submitted in October of 1994. Taking these into consideration, FHWA plans to release a final LCCA policy statement this summer. FHWA will develop training and technical assistance materials to supplement analysis techniques developed by AASHTO in the National Cooperative Highway Research Program.

Department of Transportation and Related Agencies Appropriations Act, 1995, P.L. 103-331

Provisions in each of the Department's appropriations acts for fiscal years 1995, 1996, and 1997 authorize the Secretary of Transportation to enter into grants, cooperative agreements and other transactions with any entity in execution of the Technology Reinvestment Project (TRP) conducted by the Department of Defense Advanced Research Projects Agency. The language was necessary because several of the Department's administrations did not have statutory authority to enter into "grants, cooperative agreements, or other transactions" and may be called upon to accept interagency funds transfer, award and manage TRP projects.

National Highway System Designation Act of 1995

Under the National Highway System Designation Act of 1995, the Secretary is required to establish a program for Life-Cycle Cost Analysis and Value Engineering Analysis. The Act mandates that the Secretary "establish a program to require States to conduct an analysis of the life-cycle costs of each usable project segment on the National Highway System with a cost of \$25,000,000 or more." Analysis of the life-cycle costs refers to "a process for evaluating the total economic worth of a usable project segment by analyzing initial costs and discounted future costs such as maintenance, reconstruction, rehabilitation, restoring, and resurfacing costs, over the life of the project segment."

The Act also states that the Secretary must "establish a program to require States to carry out a value engineering analysis for all projects on the National Highway System with an estimated total cost of \$25,000,000 or more." Value engineering analysis refers to a systematic process of review and analysis of a project during its design phase by a multidisciplined team of persons not involved in the project. The team's objective is to provide suggestions for reducing the total cost of the project and providing a project of equal or better quality. The outcome of such analysis may include suggestions for combining or eliminating otherwise inefficient or expensive parts of the proposed design for the project or the total redesign of the proposed project using different technologies, materials or methods.

Recommendations Regarding Future Contracting Procedures

ISTEA reauthorization represents an opportunity to update contracting procedures to encourage the adoption of advanced technologies developed through private and public surface transportation research and development. As is discussed earlier in this report, one of the Department's most important priorities over the next decade will be accelerated widespread deployment of infrastructure for metropolitan and rural areas, and for commercial vehicles.

Although innovative and flexible financing and procurement methods will be essential to the achievement of these and other departmental technology deployment objectives, ingrained state and local transportation agency financing and procurement processes have made the adoption of "true" private/public partnership arrangements difficult. The next surface transportation authorization needs to sanction innovative financing and procurement approaches, including private/public partnerships, State Infrastructure Bank (SIB) financing, electronic payment technologies, design/build contracting, life-cycle cost evaluation, and negotiated bid awards.

In addition, FTA proposes to augment its current R&D authority under 49 U.S.C. 5314 by allowing the Department to enter into grants, contracts, cooperative agreements and other agreements with consortia to promote the early deployment of innovation in mass transportation technology, services, management, or operational practices. The program would be carried out in consultation with the transit industry by competitively selecting public/private partnerships which share costs, risks, and rewards of early deployment of innovation with broad applicability. FTA also proposes the authorization of an International Mass Transportation Program, through which the Secretary would engage in activities to inform the U.S. domestic mass transportation community about technological innovations available in the international marketplace, and in activities that may afford domestic businesses the opportunity to become globally competitive in the export of mass transportation businesses and services.

